The Science of Higher Prisms.

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SCIENCE OF HIGHER PRISMS

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DEDICATED

To all those who, in order to benefit their fellow men, are willing to study and work.

CONTENTS.

The Science of Higher Prisms.

CHAPTER I.

THE THEORY.

Definition.—The Science of Higher Prisms is that branch which treats of the adaptation of prismatic glasses for the relief of ocular reflexes.

It presupposes a knowledge of the correction of errors of refraction and defects of accommodation by means of spherical and cylindrical lenses. It carries the student onward into the field of the action of the extrinsic (long) muscles of the eye-ball, and the systemic effects of any inequality of their power. It has to do with problems involving functional affections of organs remote from the eyes, and related to them only through the nervous system.

An ocular reflex is an affection of the eye, head or any other part of the body, produced by an ocular irritation of the sympathetic nervous system. This irritation is often due to a lack of balance of the opposing long muscles of the eyes.

We say "relief" advisedly, not cure, for except in those rare instances in which the trouble is simply a weakness of one muscle which may be strengthened

by Savage's "rhythmic exercise," a cure is impossible with prisms alone. But relief having been obtained by prisms, we are definitely and certainly directed to the radical cure.

Field.—Its field embraces a consideration of prisms and their action upon the eyes; the study of the anatomy and physiology of the ocular muscles, and their variations from the normal standard; the causes and effect of such variations; the instruments and methods to be used in determining these variations; and the laws governing us in their correction.

Necessity.—The necessity for this study is found in the fact that many reflexes, most evidently due to the eyes, are not removed by the use of spherical or cylindrical lenses, and that even prisms, as they are ordinarily applied, so often prove disappointing. Many a refractionist has written me, "I have tried prisms, but could never get any satisfaction out of them." My own experience was once somewhat similar. I would occasionally make a brilliant and sometimes unexpected cure of some reflex, but there were as many failures in producing comfort when prisms were apparently indicated. I blindly sought for some law or rule, not as yet enunciated, which might guide me always to a correct prescription.

The difficulty in determining what glass to use in any given case was increased by two factors: first, the unreliability of the ordinary tests, and second, the con-

flicting theories presented by writers and teachers upon the subject. In case of a cure, the systemic relief afforded was a safe criterion that in that instance, at least, the correct means had been employed. But in apparently similar cases the same treatment did not meet with uniform results. What was the reason? Was there no law of cure? There certainly must be one. It is this very important question which we are now about to discuss.

Prisms.—An optical prism is a lens, usually made of glass, whose surfaces approach each other at an angle more or less acute. Prisms are either simple or compound. A simple prism is one whose surfaces are plane. A compound prism is one in which one or both surfaces

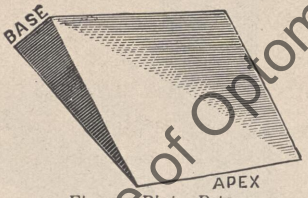


Fig. 1.—Plain Prism.

are curved. The axis of a prism is a line at right angles to its sharp edge. There is no refraction in the axis of a prism, hence to determine the axis we turn it to such a position that a straight line appears unbroken in passing through the prism; the axis then coincides with the line.

The value or amount of a prism depends upon the acuity of its angle, and is measured in the line of its axis. There are several methods of determining the amount of a prism, one of which is to neutralize it with another prism, placed base to apex, the value of the two prisms thus neutralizing each other, being equal. A simpler and more accurate method is by means of an instrument here described and called the prism measure.

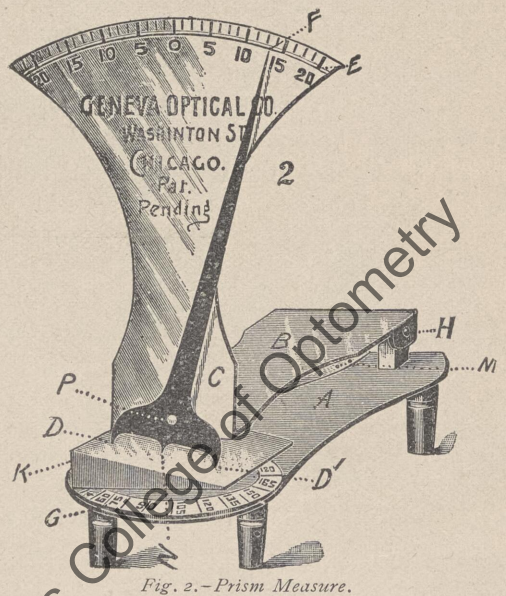


Fig. 2.–Prism Measure.

The illustration shows the instrument measuring a prism, and the position of the index finger F will be gov-

erned by the difference of the thickness of the lens at the points D D′, and the degree of the prism will be indicated on scale **E** by the pointer F. The operation is quick and exact and the value of the instrument at the present time, when so much attention is being given to the correct placing of the center of the lens, and to the adding of prisms to correct muscular defects makes this an invaluable instrument for the oculist or optician. It is handsomely made in nickel, with steel pointer. The illustration shows the simplicity and practical nature of the instrument so plainly that any oculist or optician can understand and appreciate it.

Prismatic refraction. A ray of light is always refracted toward the base of a prism through which it

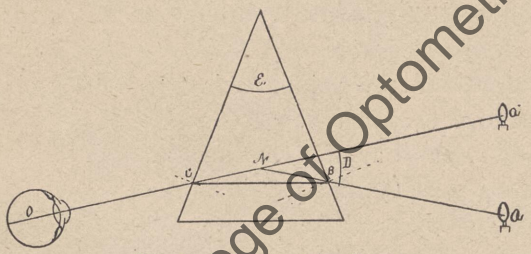


Fig. 3.—Refraction of a Prism.

passes, and an object seen through a prism always appears displaced in the direction of its apex. Hence, the eye before which a prism is placed moves in the direction of the apex in order to keep its vision fixed upon the object seen.

If, therefore, both eyes are open and a proper prism is adjusted so that the base is over the weaker (or longer) muscle, the eye at once assumes the position of repose, for the prism allows the eye to turn toward the stronger (shorter) muscle, and thus removes the strain which had been upon the weaker muscle in its effort to hold its stronger antagonist to the line of vision.

If on the contrary, the base is placed to the shorter (stronger) muscle, an additional burden is placed upon the weak muscle, for the object viewed having been moved toward the apex of the prism, and hence toward the weak muscle, this muscle must contract enough more to bring the optic axis to the (apparent) new position of the object seen.

This action of a prism upon muscles has given rise to two theories diametrically opposed to each other. One class of writers considers the balancing of the antagonistic muscles as the prime object to be sought. The other aims at the conservation of nerve force, regarding the general health as of more importance than the mere holding of the optic axis parallel.

Savage's Theory. The former group, of whom Dr. Savage, of Nashville, Tenn., is the chief exponent, consider that a prism should be used like a gymnastic pulley-weight, whose function is to antagonize the weak muscle in order to strengthen it. And to a certain extent this objective point may be attained, for the muscle is compelled to put forth greater effort in order to maintain

binocular vision. It would be but fair to Dr. Savage to quote from his "New Truths in Ophthalmology," his own words upon the subject. On page 67, in discussing the treatment of exophoria, he says: "The second method for developing the interni is by means of prisms, bases out. The prisms to be used may be from 1° to 8°, and one should be placed before each eye. The treatment should be commenced with the weaker prisms; and as development of the muscles advances, the stronger should be brought into use. The object looked at should be a candle, lamp, or gas jet, fifteen to twenty feet distant. The prisms before the eyes, the image in each of the two eyes is displaced, and the guiding sensation calls quickly into action the interni. After five seconds the interni must be allowed to relax for the same length of time (five seconds), which is readily effected by lifting the prisms up and allowing the light to enter the eyes uninfluenced. The guiding sensation at once causes the relaxation to take place, so that the yellow spots may receive the images. At the end of the five seconds, the prisms are again dropped before the eyes and the interni again contract. Then, a second time the relaxation is effected by lifting the prisms; and so on, throughout every sitting, which should last from two to ten minutes, but always be discontinued short of fatigue. The sittings should be repeated two to five times a day. While it will take weeks, if not months, to establish orthophoria, nevertheless this end can be attained in suitable cases by this method."

It is a fact that the above method does develop the power of the individual muscle, and it is true that if the only defect were lack of exercise, this method would give excellent results. But it is also a fact that by pursuing this method in most cases, a muscle anatomically longer or more tendinous than it should be is compelled to pull against one which it can never balance. And it is a further fact that by so doing energy is wasted at a tremenduously rapid rate; the reserve is depleted; the supply is liable to exhaustion, and nervous prostration only too often results. On the same principle, the author might argue that in hypermetropia we should frequently put minus glasses before the eye in order to give rhythmic exercise to the ciliary muscle.

Dr. Stevens, while commending exercise for moderately weak muscles, recommends tenotomy of the strong muscle as much the better method (p. 210, Functional Nervous Diseases), saying that at best the prisms are but a crutch and not always satisfactory.

The other class of writers, among whom may be mentioned Dr. Ranney, of New York, and Dr. Prentice, formerly of Chicago, regard as wholly immaterial the deviation of an eye, so long as the nerve centers are saved from exhaustion and distressing ocular reflexes are prevented. It is easy enough to balance the eye muscles when we have determined exactly what angle of inclination the optic axis gives them the most perfect rest. Upon this side of the controversy we will quote

first from Dr. Ranney's "Eye Strain in Health and Disease," page 137.

"At the risk of incurring criticism for repetition, I feel that I cannot impress my readers too frequently with the physiological fact that any expenditure of nervous energy in excess of that generated from day to day (irrespective of where the excessive expenditure occurs) may in time so deplete the reserve capital of nerve force in any individual as to embarrass the workings of some part or parts of the nervous system without any actual disease being present. The result of this temporary 'nervous bankruptcy' is peculiarly apt to disclose itself in some derangement of the normal function of the weakest part, as an echo is heard far from the source of the echo.

"When we stop to reflect, we can understand how every letter on a printed page, as well as every object on the street, or in our homes, that we become cognizant of by the sense of sight, requires a more or less perfect adjustment of the complicated muscular apparatus that so regulates the eyes in relation to each other as to enable them to see with both, and yet perceive but a single image. The total aggregate of such visual perceptions, during the sixteen hours of each day that we use the eyes, is enormous, and it means a proportionate number of accurately-performed adjustments of two cameras (the eyes) upon a single object, performed often with marvelous rapidity, and involving in many of the

adjustments a complete change of combinations in the eye muscles that are successively brought into play. It is not much of a task to lift a penny once, but no living being could lift a penny a million times each day. When the adjustment of the eye muscles, or the construction of the eyes themselves, is so imperfect that the maintenance of single vision (when both eyes are simultaneously used) is the result of an excessive expenditure of nerve force (far greater than nature intended in many cases), any individual so afflicted begins from birth either to draw from the reserve capital of nerve force that nature has stored up for emergencies, or the eyes must be run at the expense of a proper nerve supply to some other part (Peter being robbed to pay Paul)."

His method of relieving the nerve supply of this excessive drain, is by placing the prism with its base to the defective muscle, and later performing a tenotomy for the radical cure.

CHAPTER II.

ANATOMY OF EXTRINSIC OCULAR MUSCLES.

There are six muscles attached to the outside of each eyeball by which it is moved. These are named the superior rectus, internal rectus, inferior rectus, external rectus, superior oblique and inferior oblique. Of these all

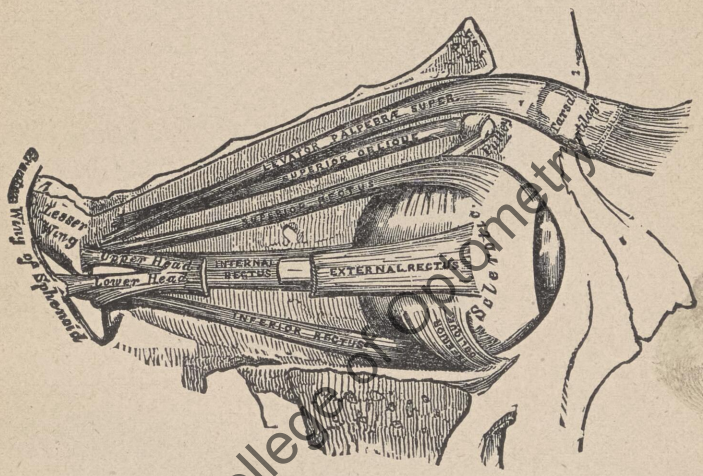


Fig. 4.

except the last mentioned arise from the bony wall at the apex of the orbit behind the eye. They diverge as they come forward. The four recti muscles pass straight to their attachment in the sclera, the tough, white outer tunic

of the eyeball, and are inserted as their names indicate; the superior upon the upper aspect, the internal upon the inner, the inferior upon the under and the external upon the outer. The superior oblique (*f*) arising in common with the four recti muscles passes forward to the upper inner angle of the front of the orbit where its tendon runs through a smooth pulley T and is reflected backward and

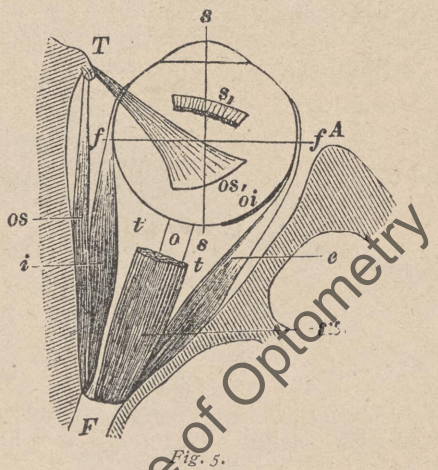


Fig. 5.

outward to be inserted into the superior aspect of the sclera beneath the superior rectus muscle and behind the equator of the eyeball.

The inferior oblique muscle arises from the floor of the orbit at the anterior edge near the internal angle, and passing outward, backward and upward under the infe-

rior rectus is inserted into the sclera on its outer aspect beneath the tendon of the external rectus, and behind the equator of the eyeball.

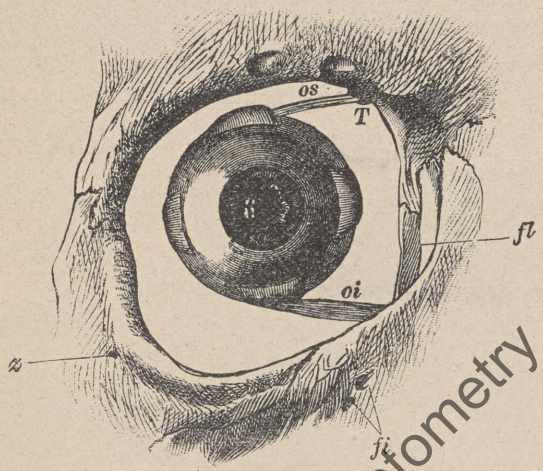


Fig. 6.

Each muscle should be studied from the accompanying cuts most carefully in order that its action may be understood.

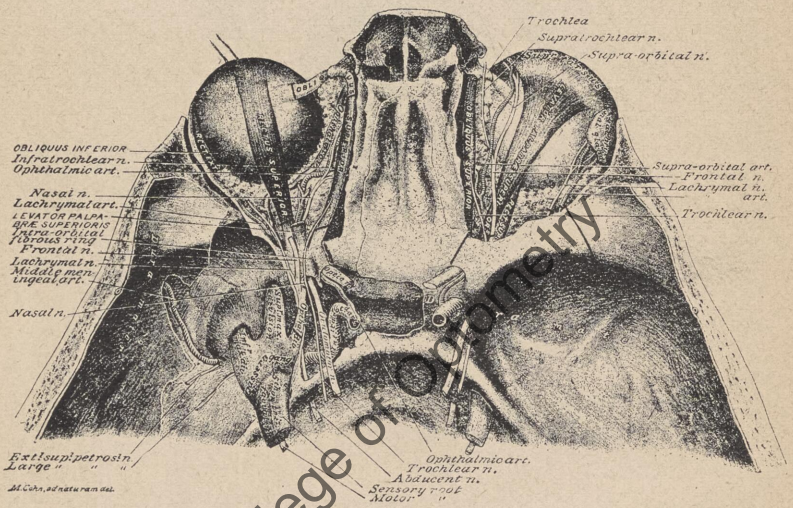
ACTION OF THE EXTRINSIC MUSCLES.

The superior recti muscles when in action cause the eyes to look upward. As they diverge somewhat in passing forward and are inserted in front of the equators of the eyeballs they slightly converge the optic axes when in excessive action. As their lines of attachment to the

sclera are somewhat obliqe (23°) to the antero-posterior diameters of the eyeballs they rotate the eyes inward.

The internal recti muscles turn the eyes directly inward.

The inferior recti muscles turn the eyes downward and secondarily they also converge the eyes and rotate them outward. In speaking of rotating the eye, it must be



†*Fig.* 7.

understood that we consider it as rotated upon its antero-posterior diameter, the point of departure being the upper end of the vertical axis of the eyeball.

The external recti turn the eyes directly outward.

†This illustration and Fig. 9 are from "Practical Human Anatomy" by F. D. Weiss, M.D. It is a valuable work which every optician should have in his library.

The superior obliques primarily rotate the eyes inward. Their secondary action is to turn each eye downward and outward. This is caused by the attachment of these muscles being behind the equator of the eyes.

The inferior obliques primarily rotate the eyes outward, each one also turns the forward end of the optic axis upward and outward.

Thus it will readily be seen that two or more muscles are concerned in almost every motion of the eyes. In fact each of the six muscles must be kept in just sufficient tension to hold the eye to the exact point of observation. For example, the right eye is turned upward by the superior rectus and the inferior oblique; outward by the external rectus and the superior and inferior obliques; downward by the inferior rectus and

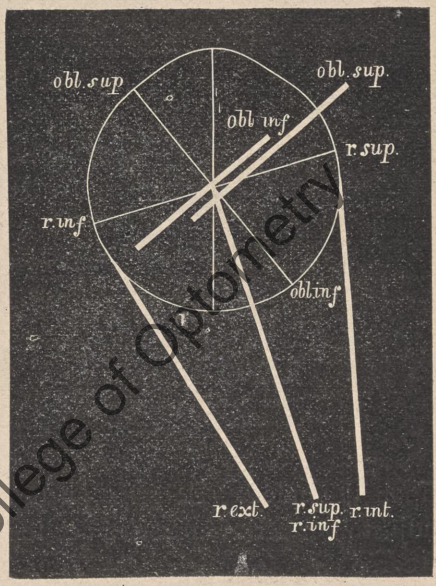


Fig. 8.

the superior oblique, and inward by the internal rectus and the superior and inferior recti.

CORRELATION OF MUSCULAR ACTION.

Every point in each retina has a corresponding point in the other so that the image formed upon the two when properly adjusted forms but a single impression

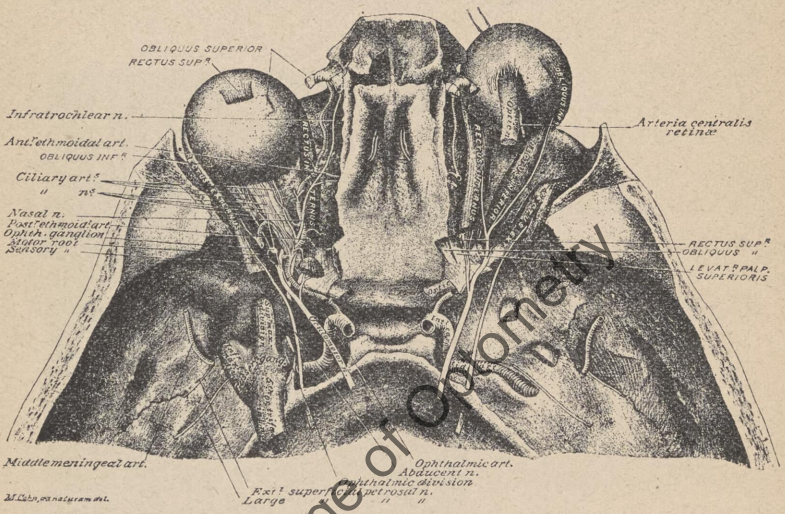


Fig. 9.

upon the mind. For the purpose of maintaining this adjustment certain muscles act together. This is called, "correlation of action." Thus in order to look at an object above the head the two superior muscles act together; to look toward the right the right external rectus and the left internal rectus (together

with the assistance of other muscles) act in concert; to look downward the two inferior recti act together; to look to the left the left external rectus and right internal rectus join forces, while in order to see an object near at hand the two internal recti cause the visual axes to converge. The two external recti never normally act together in causing the eyes to diverge except as they restore parallelism of the optic axes after an act of convergence.

ANATOMICAL DEFECTS.

Since it requires such perfect accuracy of adjustment in order that both eyes be focussed exactly upon the same object, any inequality in the development or length of corresponding muscles must put upon the weaker a strain proportional to its lack of strength. If this inequality is considerable the extra work thus devolving upon the enfeebled muscle becomes extremely exhausting not only to the eye but to the nerve centers and to the entire system. "If one member suffer all the members suffer with it."

That this anatomical inequality exists in a great many cases is shown from dissections. In very few cases are the two superior and the two inferior muscles of exactly equal weight and length. So great is this inequality that all authors have noted it.

Dr. Chalmers Prentice,* of London, England, says:

In fourteen autopsies, not one exception was found to the unequal development of long muscles. In eleven of

*(p. 11.) "The Eye in its Relation to Health."

these cases the superior rectus in the right eye or left eye was thin, tendinous and undeveloped giving evidence of having been on the stretch while that of the other eye was invariably a well developed muscle, and the converse condition of the inferior muscle was always found. In two of these eleven, the external muscles were undeveloped, while the internal showed a high state of muscular development. In one of the remaining three, an habitual drunkard and suicide, the internal muscles were thin and tendinous, the externals being highly developed; in the other two the externals were simply thin attenuated tendons the internals being highly developed. The superior and inferior muscles in the last three cases were so poorly developed that they gave no evidence of any relative difference.

"Look into the dim windows of the brain twenty-four hours after death, and a deviation of the eyes from a perfect position will always be found. They naturally fall into the positions that the relative lengths permit them to assume. But all this information comes too late for the life which is ended. Too late for aught but an apology for perhaps many a censured weakness, which after all was no more than a manifestation of some physical infirmity for which the victim was morally blameless. Under such infirmities, thus insidiously induced, but as resistless as the lightning, a Dr. Jekyll becomes a Mr. Hyde."

Dr. Geo. T. Stevens,‡ of New York, has written as follows:

‡(p. 189.) "Functional Nervous Diseases."

"In the act of binocular vision—that is, of vision in which the object seen by the two eyes makes but a single mental impresssion—the principal optic axes are in such exact relation to each other that a straight line drawn from the object through the pupil falls upon the yellow spot of the retina, the central point of vision of each eye, and at the same time each eye must be accurately adjusted in respect to its focus for the distance from it to the object seen.

"With every new adjustment of the eyes their relations must be so precisely maintained as to permit the line from the point seen to fall upon this minute portion of the retina of each eye.

"Such ever-changing and extremely nice association of actions are demanded in no other part of the organism. The movements of the extremities no matter how precise or how delicate, make no such constant demand for minute precision; and from no class of muscles other than those that direct the eyes and regulate the accommodation, is the maintenance of perfect exactitude of service so constantly required.

"That this exacting service should, when difficulties in its performance are encountered make excessive demands upon the stock of nervous energy of the individual or result in perplexities or irritations is not surprising."

Dr. A. L. Ranney, (Eye Strain in Health and Disease, p. 12) compares the normal eyes to a "high-cour-

aged horse who feels the will as well as the support of his driver through the reins by means of the bit." So it is with the normal eye. It is both controlled and supported while performing its movements within the orbit by the eye muscles (which are its reins). The brain is the driver. At its command the eye revolves or remains stationary at any desired point. The tension of muscles opposed to any movement of the eye required is so modified by the brain as to insure the requisite support to the eyeball and to steady it as it moves.

"Thus a perfect equipoise is constantly established between opposing forces, adjusted with the nicest care, to meet the full requirements of the organ under all possible circumstances. The normal eye does not tremble or wabble when it moves, or the attempt is made to hold it in any fixed attitude. It is a piece of machinery perfect in all its parts, reliable in its movements, perfectly controlled by its master.

"The eye with muscular insufficiency is like a horse with an inexperienced and incompetent driver; the proper tension upon the reins is not maintained at all times as it should be; there is no equilibrium between antagonistic muscles; fixed attitudes are maintained with difficulty for any length of time; the brain becomes more or less disturbed by its inability to properly control the eye-movements, and exhausted by the continued strain imposed upon it by the efforts required to do so even imperfectly.

"Insufficiency of ocular muscles seems to me to be a *congenital defect*. Subjects of this class are very frequently encountered in the practice of a neurologist. When a state of perfect equilibrium is impaired, the effects become manifested sooner or later by pain and great discomfort after the eyes are used for any great length of time. No glasses but prismatic ones will benefit them."

CHAPTER III.

PHOROMETERS.

In treating defects in the muscular equilibrium of the eyes, the important thing is to determine the nature and as nearly as possible the amount of the heterophoria.

This is no easy task. Every case presents a problem for the solution of which instruments of the highest perfection are required, and to which the operator must bring to bear his knowledge, skill and judgment.

No two cases are exactly alike. Hence it is necessary to know the underlying principles of the science and to be able to apply those principles to the case in hand.

Heterophoria is now recognized by all scientific writers as being divisible into the manifest and the latent quantities. The former being that which is readily detectible with the ordinary tests, and the latter that which cannot thus be at once uncovered, because it is concealed by spasm of the overworked muscle. Some instruments reveal more of the heterophoria than others as we shall presently see.

The principle underlying all phorometers (instruments which measure heterophoria) is simply to make the two eyes act independently of each other. Using a machinist's expression, it is to throw the eyes "out of gear," so that each will assume the position which the relative

length and tension of the extrinsic muscles would cause it to take if the other eye were blind.

In order to accomplish this the images formed in the two eyes must be so dissimilar that no stimulus will be sent to the eyes to make them even attempt to harmonize the images upon corresponding parts of the two retinae. In other words one image must be so discolored, displaced or distorted, that the incentive to binocular single vision will be utterly held in abeyance.

The image thus held in abeyance is called the false image, and its position relative to the true image as seen by the other eye determines the variety of manifest heterophoria which is present.

The following is an unvarying rule: The eye itself always turns in the direction of the greater muscular force, while *the false image always appears in the direction of the less muscular force.*

If we find therefore that the false image is out, we know that the eye turns in. If the false image is in, the eye turns out. If the false image is above or below the object seen by the other eye, we know that the covered eye turns in the opposite direction.

An excessive amount of heterophoria may be revealed by changing the color of one of the images. The red glass found in every trial case may be placed before one eye and the patient directed to look at a small light at a distance of twenty feet, thus causing the patient to see two lights, one red and the other the true color of the

light. There should be no other object near the flame, as a multiplicity of corresponding images stimulates to single vision.

This test is defective in that it will not reveal small amounts of error. Dr. C. M. Hobby of San Diego, Cal., has brought forward a peculiar purple glass to be used instead of the red lens, claiming that it will show all of the manifest heterophoria. This claim cannot, I think, be sustained, but from comparative tests in a large number of cases, I have found that it will reveal an error of but half the amount shown by the red glass. This lens is made by Chambers, Inskeep & Co., of Chicago.

By distorting one image we may very largely remove the stimulus to single vision. This is done by a strong convex sphere, and also by the Maddox rod. The sphere, usually a + 10. , is placed before one eye and causes the light to be so diffused that it appears as a luminous disc. If there be no manifest heterophoria the true light as seen with the uncovered eye, will appear in the center of the illumination. A deviation above, below or to the right or left of the center indicates the contrary direction of the ocular deviation. This test is defective in that a very slight decentering of so powerful a lens, from before the pupil has the effect of a prism and vitiates the value of the results obtained.

The Maddox rod is too well understood to require extended description. It distorts the flame so that it appears as a series of little flames in a row. An

improvement upon it was made by the Johnson Optical Co., of Detroit, who placed three rods side by side, the result being a more even ribbon of light. The American Optical Co., have improved upon this by making a lens of one piece, one side of which is corrugated. The

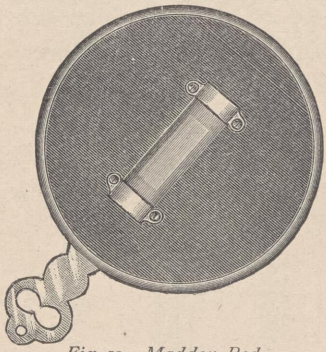


Fig. 10.—Maddox Rod.

latest improvement is by the author, who has made the lens of purple glass, the other eye being covered by a deep green glass which obscures everything except the flame. This lens may be obtained of N. Manasse Co., Chicago.

The patient is seated twenty feet from the light, and the lens is so adjusted in the trial frame that the ribbon of purple light appears horizontal. If it passes above the light there is manifest hyperphoria of the other eye; if below the light there is manifest hyperphoria of the same eye; the amount of the hyperphoria being measured by the prism which is required to bring the ribbon

directly through the flame. The rod is then so placed as to cause the ribbon to run vertically when the manifest esophoria or exophoria is revealed.

The test is simple, easily applied, and usually quite reliable, especially if the rod is accurately made and the

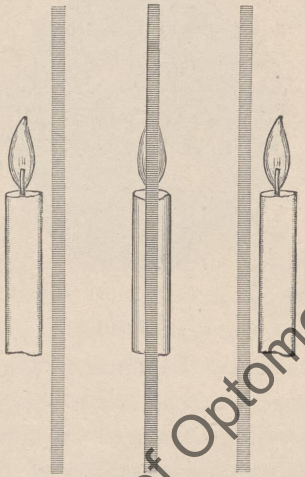


Fig. 11.—Maddox Rod Tests.

aperture in the black disk containing the rod is narrow. The only defect of this appliance is that if the glasses which correct the refraction are very strong they are quite liable to give a prismatic effect. For ordinary use, however, I consider it one of the most valuable appliances we have.

Several methods are in use whereby one image is displaced vertically or horizontally ten or more degrees, so

that the stimulus to single vision is suspended. The relative position of the two images thus seen depends upon the variety of manifest heterophoria or orthophoria present.

The defect of this device as used in the trial frame is that the axis of the prism may not be accurately adjusted in the frame. A slight tilting of the head to one side or the other will produce an apparent hyperphoria where perhaps none exists. The first defect is obviated by the arrangement of the prisms in Steven's Phorometer, made by Meyrowitz of New York. A spirit level indicates the horizontal position of instrument. It also possesses another advantage in that it leaves the trial frames free, for both spherical and cylindrical lenses to correct any existing errors of refraction.

The only objection to the instrument is that the distance between the lights is usually so great that it is difficult for the patient to decide whether they are exactly horizontal in the horizontal position. My own experience is that hyperphoria is more accurately measured by the Maddox rod, because the ribbon passes so close to the light that the slightest deviation is perceived.

On the other hand I find that Stevens' Phorometer will in many cases reveal more lateral deviation, especially exophoria, than the Maddox rod. The reason for this is that with the phorometer both eyes are fixed upon a distant light, whereas the ribbon produced by the rod often appears to the patient as if close to his face and

hence in looking at it he exercises a certain amount of accommodation, and as a correllary he brings into action the internal recti muscles, thus partially vitiating the result of the test.

The Maddox double-prism test has some advantages in that it gives two false images with which to compare the position of the true one. At the near point it at once determines the existence of manifest exophoria and hyperphoria and is the best test yet devised for testing cyclophoria. (See New Truths in Ophthalmology, p. 26.) The distant test is however of less value because of the distance of the true and false images from each other.

The Prince Phorometer has an advantage in that the turning of a thumbscrew measures the amount of the manifest muscular deviation, thus saving much time and doing away with the necessity of using numerous prisms for the same purpose.

The Wilson Phorometer, while introducing no principle other than those described above, has been a great boon to the busy practitioner, in that the rapidity with which it enables him to make these muscle tests saves him much time and labor. The patient is also less fatigued and therefore the results obtained are freer from errors due to muscular weariness. The instrument combines in a compact and convenient shape, all of the standard tests now universally in use. Each one may be seud in turn, the one confirming or disproving the accur-

acy of the others. These are so arranged that each of the three methods of disguising the false image, namely distortion, displacement and discoloration may be brought into play at one time. Its reasonable price and the ease and accuracy with which it is operated, has made it very popular with refractionists. It is handled by the Geneva Optical Co., of Chicago.

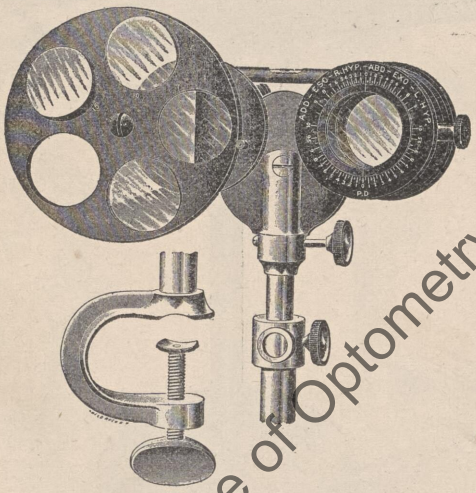


Fig. 12. The Wilson Phorometer.

This same company some time ago produced the Optomyometer, which is a very ingenious device for measuring heterophoria. It consists of two tubes, so arranged that no matter what the deviation from parallelism of the optic axis may be, each eye may see the light

through its own tube and a pointer indicates the amount and nature of the heterophoria.

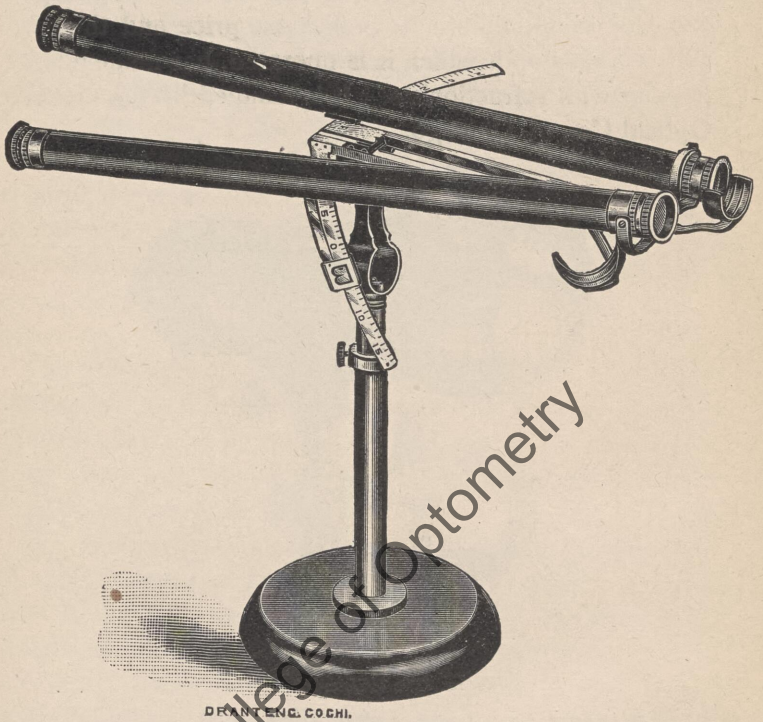


Fig. 13. Optomyometer.

So much latent heterophoria may exist in any given case that the ordinary tests reveal but a moity of the trouble present, in fact often none of it at all. In such cases we have to resort to a test of the strength of each

group of coordinate muscles. No examination is complete which does not record the abduction, adduction and surcumduction of the eyes. This is determined by finding the strongest prism with which the two eyes will see

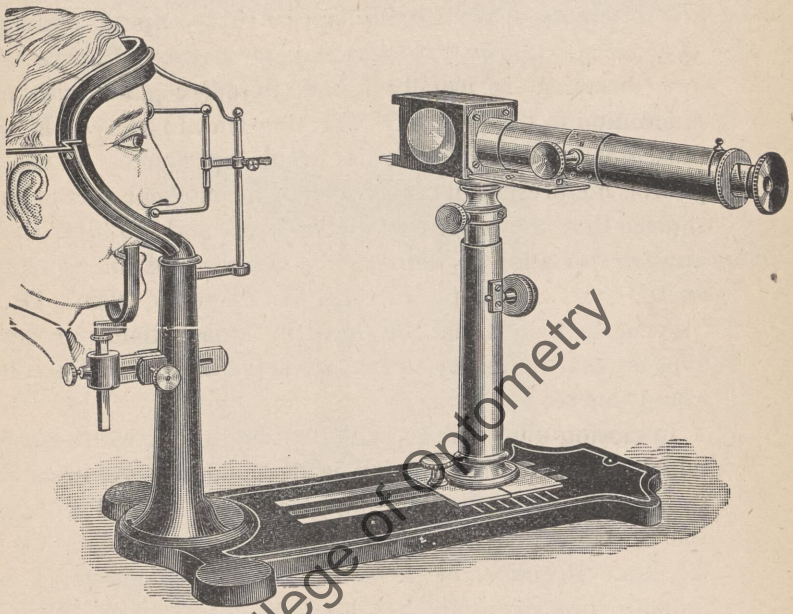


Fig. 14. Tropometer.

a light singly, the prism being placed with base in, out, up and down before each eye.

Stevens has invented an instrument with which we may even go a step further and determine the absolute arc of rotation of each eye separately. He has named it the

Tropometer. It consists of a head rest so arranged that the head is held immovable, while the eyes are turned out and in, up and down; a telescope through which a reflection of the eye may be seen in an oblique mirror; and an eye-piece with a scale of degrees marked upon it. The normal eye usually can be turned up 33°, down 55°, out 40° and in 50°. An excess of these figures in any direction is usually found to correspond with a diminution in the opposite direction and to show which muscle is too powerful for its weak opponent. If esophoria be present it reveals which external rectus is shorter than the other. If both eyes stand too high the upward deviation of both will be in excess of the figures named, and an anaphoria be thus found to exist. Dr. Stevens says of it that the upward turning ability of the eyes is usually the key to the whole trouble, and I have found this true.

In closing allow me to call attention to one instrument which in my humble opinion is destined to revolutionize the present methods of fitting glasses. It is the Prentice Retinoscope, and was invented by the justly famed Dr. Chalmer Prentice, of London, Eng. It consists of a metallic tube twenty inches long, mounted upon a stand. The patient is seated so as to look into one end while the operator views the shadows in his eye through a retinoscopic mirror at the other. The light is admitted to the mirror through another tube placed at such an angle that it is reflected directly into the patient's eye, while all side

lights are cut off by the blackened interior, and by a series of interposing diaphragms. At the patient's end of the tube are two dials filled with lenses and operated by a thumb screw near the observer. This gives a range of two-hundred one-eighth dioptre measures of hyperopic

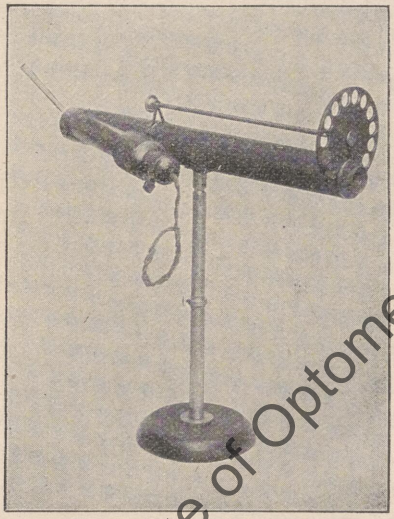


Fig. 15. Perrine Retinoscope.

andmy opic correction. The instrument itself is a model of scientific accuracy, and by means of it the shadow will reverse so as to measure the refraction in any axis to within an eighth of a dioptre.

This invention is destined to be to the science of refraction what the ophthalmoscope is to that of ophthal-

mology. It is objective, hence does not subject the operator to the confusion which contradictory answers of the patient give to his questions. It is objective and hence may be used upon the illiterate, the foreigner and the deaf mute.

It measures the refraction of the entire dioptric sysem of the eye, and hence is vastly superior to the ophthalmometer, which simply measures the astigmatism of the cornea, and does not even tell us how much of it is really hyperopic or myopic.

It has a great advantage over retinoscopy as usually practiced, in that the distance is a fixed quantity; it can be operated with great rapidity, and does away with the necessity of a dark room for refractive work. A clip at the side of the patient's eye-piece will hold a plus 4.^{D} glass, thus fogging vision, relaxing the accommodation and dilating the pupil. This gives a clear defined shadow in a brilliant illumination and the astigmatic bands are clearly seen. It is made by the Geneva Optical Co. of Chicago. Every oculist and progressive optician who has seen it has ordered one, and judging by the advance sales it is going to be very popular.

The source of light by a series of condensers is focused exactly on the mirror, and being but 6 inches away gives a brilliant illumination. The rotations of the mirror are so limited that the light reflex can never be lost by passing the area of the pupil and is always in focus.

CHAPTER IV.

EXOPHORIA.

Definition.—Exophoria is from a Greek word meaning *Outward tending*, and is that condition in which there is a tendency of the eyes to turn out or diverge. It is sometimes called invisible divergent squint, because while the tendency to diverge exists the optic axes are held to their places by an excessive nerve impulse sent to the *internal recti*, the muscles, whose duty it is to counteract this tendency toward divergence. When the eyes do actually turn away from each other the exophoria has passed over to an exotropia and the strabismus has become visible. This accident usually occurs when the exophoria exceeds 20° and yet many cases are on record where the stimulus to single vision overcomes an exophoria of from 50° to 90° so that the optic axes are held parallel in spite of this excessive strain.

Occurrence.—Exophoria is exceedingly common. In fact the majority of persons suffering from eye-strain have it in a greater or less degree. It is the cause of many ocular reflexes and frequently underlies other heterophoriæ which are spasmodic and which disappear when the original exophoria is corrected.

Varieties.—There are three varieties of exophoria, viz.: the manifest, the latent, and the reverse. Manifest

exophoria is that which is revealed by diffusion tests as ordinarily used, which are hereafter described. Latent exophoria is that which is wholly concealed from diffusion tests as ordinarily used, and which can only be brought to light by repression, as explained later. Reverse exophoria is that condition in which while a true exophoria exists in fact, yet so great is the effort on the part of the nerve centers to overcome its manifestation that an excess of nerve impulse is sent to the *internal recti*, thus throwing them into spasmodic contraction and not only concealing the exophoria completely, but even carrying the eyes so far inward that the ordinary tests reveal a seeming esophoria. Relative exophoria is exophoria as compared with esophoria, while individual exophoria is exophoria of one external rectus muscle as compared with the other. It is not enough to know that relative exophoria exists; we must know which of the external recti is most at fault in order that our treatment may be scientific and accurate.

Causation.—The action of the *external recti* muscles is to cause the eyes to diverge, or, in other words, to antagonize the action of the *internal recti* which converge the eyes for near work. The *external recti* are usually shorter than their antagonists. Hence if both pairs were equally developed and were to receive equal nerve impulses, the eyes would turn outward. In the lower animals this tendency toward divergence is very manifest. Observe the eye of the horse, the cow or

other animals. While both eyes can be directed forward to the same point, each eye can also turn away from the other. The lower animals never become cross-eyed because exophoria is the natural condition of animal life. In order to prevent exotropia in man, nature has employed three counteracting agencies. First, the insertion of the *external recti* is further back than that of the *internal;* second, the *superior* and *inferior recti* when in excessive action aid the *internal recti;* and third, the desire for single vision causes an unequal distribution of nerve impulse, so that a much greater amount is sent to the *internal recti.* This is shown by the fact that the eyes can be converged at will for near work.

Anything which overtaxes the *internal recti*, as excessive use at the near point, or which weakens the nerve centers in the brain, as prolonged sickness, parturition, etc., impairs the resistance of the *internal recti*, and the eyes tend to turn in the direction of the short or external muscles. If in spite of this tendency to diverge, the eyes are held straight it is at the expense of the nerve force, and the greater the effort to keep the optic axes parallel the greater the nerve loss. It is much more important that the nerve force be conserved than that the eyes should be straight. Hence prisms should be so adjusted as to relieve the strain, even though the eyes diverge visibly.

Other causes which lead to divergence are paralysis of an *internal rectus*, or a too free division of the internal

tendon for the cure of cross-eye. Fright, whooping cough, the loss of one eye, great impairment of sight, as in myopia, and a host of other accidents bring to light a latent exophoria; but to say that they cause the exophoria would be incorrect.

Manifestation.—Divergence is frequently observed in the eyes of the new-born child before the incentive to single vision has asserted its supremacy. After death, when the *rigor- mortis* has passed and all nerve impulse is absent, the eyes assume the position which the relative length of all the long muscles induces. This is more frequently divergent strabismus than anything else. But then alas! the diagnosis is too late to be of service. Such was the case with the late Mr. A. L. Smith, president of the Geneva Optical Company. He had an exophoria of nearly 90° which was mostly latent and was wholly concealed during life, and which, had it been corrected in time by higher prisms might not have so sadly undermined his vitality as to cause his premature death.

Myopia is frequently associated with exophoria but the latter condition and the strain reflexed therefrom, to the ciliary muscle is more often the cause of the myopia than the reverse. Protracted illness, child-birth, lactation, long continued eye strain or anything which impairs the nerve energy is liable to change a latent to a manifest exophoria.

By art we may effect the same result by placing strong prisms before the eyes bases in. Strong plus spheres

also assist in transforming a reverse or latent to a manifest exophoria or even an exotropia.

Symptoms.—Any of the following and many others may be present. Eyes tire on near use. Aching at the inner corners of the eyes. Eyes hot and dry; feel as if sticks were in the eyes; stiff drawing sensation in muscles on moving the eyes. Lids heavy, feel as if they must be propped open. Pain shooting up from the eyes. Letters blur or appear double, or run together. Amblyopia. Myopia. Brain feels as if squeezed, dull, stupid. Melancholia. (See Hyperphoria.)

Latent exophoria gives rise to great nervous loss, and the symptoms, thereby produced are legion. On the other muscles of the eye it produces spasmodic contraction, resulting in esophoria, hyperphoria, cyclophoria. On the nervous system it occasions many reflex disturbances, irritation, spasms and paralyses.

On the mind it causes insanity. Dr. Ranney reports three cases, and Prentice two cases of insanity as due to exophoria. I have reported in a recent issue of the *American Jeweler* a severe case of melancholia perfectly cured by removing this defect. (See Hyperphoria.)

On the sensorium, headache. More cases of headache are due to ocular defects than to all other causes combined. Astigmatism, hypermetropia and exophoria are the eye conditions which most often give rise to this reflex.

On the ears, deafness, ringing. Not that all deafness is due to it, but a number of authentic cases have been

reported as directly resulting from exophoria. This was proven by the fact that the removal of the ocular unbalance was immediately followed by the disappearance of the deafness.

On the throat, paresis, inability to talk.

On the face, neuralgia. I have recently cured a remarkable case of facial neuralgia which returned each month, in a lady whose sufferings were terrible. In all 13 degrees were uncovered and removed, although none showed on first examination. For six months now she has been entirely free from the affection.

On the lungs, asthma, hay fever, tuberculosis. Not that it produces these diseases, but it so lowers the vitality that the patient readily falls a victim to the diseases.

On the stomach, nervous dyspepsia. (See Hyperphoria.) Dr. Ranney devotes an entire chapter to the discussion of this subject.

On the bowels, constipation. All cases of constipation are not due to exophoria, but where it exists in great quantity it generally produces constipation. Several years ago I told a bicycle dealer that his wife's terrible constipation could be cured by glasses. "I will give you the best wheel in the store if you will cure her," he exclaimed. I took his offer and used the wheel all the following summer, and then sold it for enough to pay for my work.

On the female sexual organs, dysmenorrhœa, amenorrhœa. Dr. Prentice has recorded a number of such cases

cured. In all medical works there is a noticeable relationship between the eye symptoms and those of menstrual irregularities.

On the male sexual organs, prostatitis, profligacy. Not by any means that all cases of excesses are due to exophoria. But given an irritable prostate, here is an irritant which reflexes upon it, while at the same time it depresses the physical, and hence the moral resistant power of the man.

On the liver and kidneys, diabetes. (See Esophoria.) Diabetes was formerly supposed to be a disease of the kidneys. Then it was found that the kidneys simply eliminated the sugar produced by the liver. Then that the hepatic irritation came from the floor of the fourth ventrical in the brain, and now that this irritation is produced by an anatomical irregularity of the ocular muscles, causing eye-strain.

On the spine, locomotor ataxia, paralysis agitans, inability to walk. (See Esophoria.) Numerous cases will be cited as we progress to show the marvelous relationship between ocular unbalance and inability to walk straight.

Detection and Measurement.—A. Of *Manifest Exophoria.*

(a) By card. Cover one eye with a card, the eye remaining open, and have the patient look steadily at a light for some moments, then while you are watching the covered eye change the card to the other eye, and see if the eye first covered moves inward (toward the

nose) to catch the light. Do this with the light at twenty feet and also at fifteen inches.

(b) By overtaxing. Seating the patient directly in front of you hold a pencil vertically a foot in front of his face and slowly move it toward him, telling him to continue looking steadily at it. If there is considerable manifest exophoria one eye will presently begin to turn away while the other follows the pencil. In case of paralysis of one internal rectus the eye to which it belongs cannot be turned toward the nose even when looking at a distant object.

(c) By red glass. In a darkened room seat the patient at a distance of twenty feet from a light, and place upon his face a trial frame containing one red, and one plain clear glass. If there is a considerable manifest exophoria two lights may be seen, the red being to the opposite (nasal) side from the eye having the red glass.

The purple glass of Chambers, Inskeep & Co. reveals nearly twice as much exophoria as the ordinary red glass of the trial cases.

(d) By Maddox rod. In a darkened room seat the patient twenty feet from a small, bright light. This may be a gas jet turned down, or better, an electric light covered with a black metallic shield, through which a round hole one-fourth inch in diameter allows a single pencil of rays to shine to the patient. In the trial frame place before the better eye a Maddox rod with its axis horizontal. When both eyes are open a vertical streak of light

will be seen passing either through the light or to the right or left of it. If there is manifest exophoria for distance the streak will pass to the opposite or nasal side of the light about as many inches as there are degrees of manifest exophoria. The author's modification of the multiple rod in purple, the other eye being covered with green glass, reveals more of the exophoria. Then have the patient approach to within twelve inches of the light and test again, as it often happens that there is apparent esophoria at a distance, but exophoria at the near point. Such cases are exophoric. When there is exophoria at distance and esophoria at near point, even with a strong plus sphere before each eye, it indicates latent hyperphoria.

(e) By double prism. Place in the trial frame before the better eye a metallic disc containing two 6° prisms, base to base, with the slit between the prisms horizontal. The other eye should be covered. Direct the patient to look at a card on which is a broad, black line with a cross at its center. The card should be held fourteen inches from the face with the line horizontal. Two lines will be seen through the double prism. Now uncover the other eye and a third line will be seen between the first two (unless there is marked hyperphoria). The crosses in the middle of the lines should be one directly above the other. If there is manifest exophoria the two crosses seen through the double prism will be to the opposite or nasal side of the central cross.

(f) By single prism. Hold a 6° prism, base down, before one eye, both eyes being open, and direct the patient to look at a white spot on a dark back ground twenty feet away. Two spots will be seen. If there is manifest exophoria for distance, the upper spot seen through the prism, will be to the opposite or nasal side of a vertical line passing through the lower spot. Stephens' phorometer is constructed on this principle, and is better than the trial frame.

The author's phorometer, manufactured by L. Manasse Co., brings into use all of the principles above described.

Then test at the near point, substituting as the object looked at a white card with a black spot on it.

CHAPTER V.

LATENT EXOPHORIA.

B. Latent Exophoria.—If from the symptoms of nerve loss, latent exophoria is suspected, we may uncover it by placing upon the patient prisms, bases in, beginning always with very weak degrees, say 2°-4° for *constant use.* By constant, I mean incessant. If the patient lays them off for a single half hour, he may lose all he has gained in an entire day by their use, as the spasm of the internal recti very quickly returns after being relaxed. Gradually increase the strength 2°-4° each day or week as the patient is able to bear it, always stopping a little short of the limit of fusion. To find this limit place in the trial frame successively stronger prisms bases in, until you find one with which he can no longer hold distant objects single; then go back a degree or two. If there is latent exophoria the limit of fusion will gradually become higher and higher. Suppose for example on first seeing a patient there is no manifest heterophoria, but you suspect latent exophoria. He can fuse, we will say 6° base in. Give him 3°. On next seeing him you find that he can fuse 8° base in, you give him 6°. Next time he can fuse 11°, you give him 10°. Next time he can fuse 12°, you give him 11.° Or the evolution may be much more

rapid, as in one of my cases in which on first testing I found the lady could fuse 8°. I gave 4°. One week later she could fuse 28° and I immediately operated, curing her completely of a paralysis of several weeks standing.

To get more rapid action, have patient come daily and place in the trial frames the strongest plus glass with which he can see to read at twelve inches, and then add the strongest prisms bases in, with which the patient can fuse at the same distance, and have him read constantly for several hours, daily increasing both sphere and prism to the above mentioned extreme. This method will frequently be followed in a few hours by a marked relaxation of the *interni* when you had apparently reached the limits with the first test. If this gives relief it is right. If it aggravates it is not.

If there is marked myopia present, combine with the prisms the weakest minus glass with which the patient can see $\frac{20}{80}$ and you will reduce the myopia as you increase the manifest exophoria.

If, on the other hand, there is hypermetropia, give prisms until all the manifest exophoria is corrected and then add plus spheres little by little until you have fogged his vision to $\frac{20}{80}$ for constant use. In this way you can uncover a latent hypermetropia to a much greater extent than you can with atropine, while you avoid many of the disagreeable effects of the drug.

In testing the fusion power of the eyes care must be taken first that the two objects are not so far separated

that one of them is entirely out of the field of vision, and second, that the image of the object seen by the poorer eye is not suppressed. To avoid the former begin with low prisms and work up gradually; also have a large field and a bright striking object. To avoid the second error correct the vision of the poorer eye as much as possible and then fog the better eye with plus spheres until the visual power of the two eyes is nearly equal.

C. Reverse Exophoria.—The same methods which have been described in dealing with latent exophoria must be used with even greater care in the reverse variety, because of the fact that in this class of cases there is terrible loss of nerve force and great reflex irritability of the entire nervous system, rendering the patients hypersensitive to every influence and impression. They will frequently declare that the glasses are "killing them," that it "breaks their backs" to wear them, that they "can't stand it."

Such people must be handled with great firmness, associated with great gentleness. You must explain the ultimate object which you seek. You must tell them beforehand of the inconvenience which the glasses will be to them in making the ground rise before them and in fogging their vision. You must tell them that it may take a dozen pairs of glasses to fit them. If they are unable to mount a flight of stairs at one leap, but must go up one step at a time, so it may be you can correct only a small part of the trouble each time, especially at

the beginning. You may even have to put a weak solution of atropine into the eyes in order to get them to begin the wearing of glasses. But once started there is little trouble. You may say that this is not practical. That depends entirely upon *you*. This condition gives rise to the most serious consequences. If you yourself are sufficiently impressed with its gravity to impress your patient that the treatment *must* be pursued, and that the disease *will* yield to it, you can do what you find necessary. Otherwise you will fail.

One case in point: March 6, '99, H. W. W., aged 18, sent by L. Manasse Co., came to me complaining of poor sight and headache. He was very pale and anaemic, with strong consumptive tendencies. He showed exophoria of 6° distance and 13° near. ℞ 4° base in. March 21, better. Exophoria 10° distance and 14° near. ℞ 10°. April 5, complained greatly that glasses were too strong; made him feel weak and faint. Declared he could not and would not wear them. I prescribed 14° and insisted that he wear them.

I saw nothing more of him until September 11, when he came in, saying he never felt better. He was strong and had a healthful color in his face, although he had had no vacation this Summer. Exophoria 16° distance. ℞ 16°.

Repression by means of strong plus spheres and higher prisms for reverse exophoria is a very difficult but a very successful method of relieving nervous tension. Little

by little increase the fog until the muscles relax and the patient complains that he feels weak. This is a most encouraging sign, as it shows that you are on the verge of victory. Sometimes a chronic spasm of the *interni* after long resistance will yield in a moment. The weakness will pass away with good food and care, provided you hold tenaciously to what you have acquired.

Sometimes reverse exophoria is associated with high degrees of hypermetropia. The effort of the ciliary muscles to overcome the error of refraction is reflexed to the internal *recti* and cross-eye may be produced. A short time ago I had such a case under treatment. A child of three years had a hyperopia of 7. D. He was wearing + 6 D, and his eyes were straight, but if I took the glasses off for a moment, immediately one eye turned in at least 45°, and yet with the glasses on there was slight manifest exophoria. When I began treating him he was totally deaf, dumb and stupid and could not walk. Now, with no other treatment than glasses, he hears loud noise, he runs alone, is playful, notices everything and makes considerable noise with his vocal organs.

Remember that whether the esophoria be true or false, you must correct as much of the hypermetropia as possible, and that when the latter is corrected a false esophoria (i. e. a reverse exophoria) will be more easily detected and cured. Hence, fog such a patient if necessary, even to the extent of $\frac{20}{100}$ and have him wear the glasses constantly.

It is in such cases as this that a tenotomy of an internal rectus for cross-eye is followed in time by a divergent strabismus. Hence, an internal rectus should never be cut in squint, until every effort has been made to uncover a possible reverse exophoria.

The general symptoms following repression in latent exophoria are the only certain proof that you are on the rihgt track. If these are favorable, well and good. If they are unfavorable, you must look elsewhere for the cause of the trouble.

Relationship. — a. To hypermetropia. Both exophoria and hypermetropia frequently coexist, and each aggravates the eye-strain produced by the other. You cannot, with comfort to the patient, correct all of the refractive error while ignoring the muscular insufficiency. This is the reason why some of your patients cannot wear the glasses you have so carefully prescribed. *First correct the manifest exophoria, and then you will have no difficulty in correcting the hypermetropia.* Conversely correcting all the manifest hypermetropia assists in revealing a latent exophoria.

b. To myopia. When exophoria is associated with myopia you find that the patient desires the strongest minus glasses with which he can see. These become a source of great danger and positive injury, as they cause the near-sightedness to increase rapidly. Thus the "vicious circle" is established; the greater the myopia the stronger the glasses required, and the stronger the

glasses worn the greater the myopia. Those cases of progressive myopia which frequently end in virtual blindness are always exophoric and hyperphoric. I have had many cases in which by correcting the heterophoria I have improved vision and relieved the eye-strain, and been enabled to greatly reduce the minus sphere. *Correction of the manifest exophoria helps to reduce the minus spheres.*

c. To esophoria. Apparent esophoria is frequently reversed exophoria, due to spasm of the internal recti. Cases of apparent esophoria at a distance and exophoria at the near point are always exophoric. *Correct the hypermetropia first and the exophoria later.* (See esophoria.)

d. To hyperphoria. Both exophoria and hyperphoria may coexist, but frequently the apparent hyperphoria is a reflex from the exophoric strain. Cases of exophoria at a distance, and esophoria near, are hyperphoric. *Correct the manifest exophoria first.* (See hyperphoria.)

e. To cyclophoria. Cyclophoria is usually reflex from oblique astigmatism associated with exophoria and hyperphoria. *Correct the manifest exophoria first.* (See cyclophoria.)

f. To astigmatism. Irregular refraction is frequently due in part to heterophoria. When you correct the latter the former is markedly reduced. Hence, always *slightly undercorrect the astigmatism, but put on all the plus sphere you can, (or reduce the minus sphere), and correct the exophoria.*

CHAPTER VI.

CORRECTION OF EXOPHORIA.

Two methods have been advocated for the correction exophoria. 1st Savage's, viz., to place the prisms bases out, and thus "develop the weak internal recti by rhythmic exercises," thus "balancing" the eyes. 2nd. Prentice's, which is in reality Thomas' carried to an extreme, viz., to place the bases of the prisms in, and thus relieve the nerve center of strain. The advice of Savage is based on the theory that the exophoria is generally due to inherent weakness of the internal recti. This is evidently incorrect, as it is possible to produce an artificial esophoria in an exophoric patient by prisms; but at the time you do so the nerve centres are greatly depleted of their reserve power by the excessive drain thus produced. Hence, the esophoria produced is of central, not peripheral origin. The advice of Prentice is based on the theory that the exophoria is due to a too short external rectus, and his treatment is proved to be the correct one by the fact that when the prisms are prescribed as he advises, there is a relaxation of spasmodic tension of the entire system, and a renewal of nervous force.

The treatment of manifest exophoria is very simple. It consists of placing before the eyes prisms with their bases toward the nose, beginning with weak powers and

increasing as rapidly as the patient can comfortably bear the changes, until the full measure of the exophoria is reached.

It is well to explain to a patient that they cannot endure their full correction at first, but that if it is attained by successive stages they will not only tolerate but be greatly helped by the glasses. It is like climbing a flight of stairs. They cannot go from the bottom to the top at one step, but by going up one stair at a time they can reach the top. So here there is a limit to the exophoria; when that is reached and corrected there will be no more manifested.

Begin the correction, therefore, with weak prisms of 1°-4° strength, bases in; the less the manifest exophoria and the greater the sensitiveness of the patient, the weaker should be the first pair of prisms.

Inform the patient plainly that at first he may not see as well with the glasses as without them, and that for the first few days the ground will probably appear to rise before him, but that after a week it will all be right. He should also be warned that he is liable to stumble in walking over rough ground or stepping up or down, for a few days. He may even be slightly nauseated.

In a few days retest the muscles, when you will probably find more exophoria manifest. Increase the strength of the prisms accordingly 1°-4° at a time, generally not exceeding the manifest exophoria. Repeat this process over and over again, giving higher prisms each time,

until you arrive at the permanent limit of exophoria for distance. When your patient has 12° of exophoria for distance, and can fuse 20°-30° base in, a tenotomy of the external tendon of the poorer eye should be made, and the subsequent treatment pursued as described in the lecture "Operations."

In latent and reverse exophoria we must watch not only the development of the manifest portion, but also the effect upon the general system. If we set forth upon the theory that everybody has exophoria we will soon get into trouble, for such is not the case. And again, where a patient has five or six degrees, if we attempt to force upon him a ten degree prism his eyes will resent such interference, even though he was helped with a prism of six degrees. Very little, if any, harm can be done by giving too strong a prism base in for temporary use. The worst that can be said against a too strong prism is that it is uncomfortable, it produces unsteadiness in gait and a feeling as if one were climbing a hill when walking, and very rarely it causes fainting and backache. But the local discomfort to the eyes is usually so great that unless you know there is much more of the trouble concealed, it is wise to desist from the pursuit of the latent exophoria and attempt to uncover some other defect, or possibly to go back to the glass which was most comfortable and let the patient wear that for some weeks or even months.

The rapidity with which a latent exophoria becomes

manifest varies greatly in different individuals and at different ages of life. I have seen a case in which an apparent esophoria of three degrees for distance, with an exophoria of 15° at the near point, showed a manifest exophoria of 15° for distance inside of ten days. I have now under treatment a young woman aged 31, who has been a great sufferer with headache all her life. Seven months ago she manifested + 1.D of hypermetropia and 2° of exophoria. This was corrected with glasses, when she showed more, and each week, although I fully corrected all the manifest hypermetropia and slightly overcorrected the manifest exophoria for distance, yet the next week I would find that she had outgrown her glasses. Twice I have operated, removing radically 15° the first time and 12° the second, but last week she reappeared with 6° of manifest exophoria for distance and 10° at the near point. How much more she has I cannot tell, but the headaches which formerly made her nearly crazy all the time, are now of rare occurrence and not severe, hence we have reason to believe we are approaching the limit of the trouble.

One precaution I wish to urge, and that is to always test the muscular balance at the near point, for in some cases you will find more manifest exophoria for distance than for near vision, even though you use a strong plus reading glass with the latter test. Such cases are hyperphoric, and an over correction of the exophoria will conceal the hyperphoria.

Our knowledge or estimate of the distance of any object from us depends largely upon the effort put forth by the internal recti muscles in directing the vision toward it. The prisms change the amount of effort required, and hence when the bases are inward objects appear nearer than they are, and when outward, farther away. The uncertainty of effort at first required is what causes the nausea, in the same way that it is produced by the rolling of a ship at sea, or the taking of such a drug as gelseminum, whose action is to partially paralyze the interni.

When the exophoria is associated with hypermetropia, myopia or astigmatism, follow the rules laid down under the head of "Relationship." When there is much latent, or reverse exophoria, giving rise to marked nervous disturbances, it is sometimes difficult to induce the spasm of the internal recti to relax. This is especially the case in elderly people who have been great readers. The abnormal nerve impulse has become fixed, and is almost as inflexible as steel. Such cases often yield at the near point, when they are entirely rebellious at a distance. Have patients come daily, and while sitting in the office crowd on all the plus sphere with which they can see at 12 inches, then add all of the prism, base in, with which they can fuse at the same distance, and have them read a great deal, constantly endeavoring to hold the print farther from the face. Also, for distance, in such cases, put on plus glasses, until the vision is fogged to $\frac{20}{40}$ or more, and add

all the prism, base in, with which they can fuse, showing them that the glasses are temporary, and are not for the purpose of helping their vision, but for the higher purpose of relieving the nerve centers of the drain, so that nature may be sufficiently recuperated to resist and overcome the morbific influence, whatever it may be.

In reverse exophoria, when there are several errors, such as hypermetropia, exophoria and hyperphoria, all latent, it is sometimes very difficult to unlock the combination. By fogging severely for a few days, and then crowding on all the prism, base in, with which the patient can fuse, it will yield little by little. Sometimes a patient will only fuse at a distance with a few degrees, say 4°. Put on 5°, and have him look at your finger held near his face. When he sees it single, slowly move away until you are at a distance of 20 feet. He will now see the letters single. Leave that glass on for a few minutes, and then substitute a stronger prism, and then repeat the manœuver, and continue little by little to bring all the fusion-power to light.

Always divide the strength of the prism between the two eyes. Thus if he can fuse 16°, base in, for distance, and you wish to give him 15°, put 8° before one eye, and 7° before the other. Next time you can probably change the 7° to 9° or 10°, saving the 8° prism until the time following, and thus save your patient some expense.

How often shall you change? That depends upon the rapidity with which the internal recti relax. I usually

retest once a week, and if there is great nervous prostration, every day. If there is no change, I have the patient continue the same glass for another week.

Prognosis.—In some cases, especially where there is considerable manifest exophoria, you will reach the permanent limit in a short time (see Operations). In others, where there is reverse exophoria of years' standing, it may take months of patient work to bring the defect to light and correct it.

If you sufficiently impress your patient with the importance of the object aimed at, and assure him, as you honestly can, that the time will come when, after a tenotomy perhaps, he can either go without glasses, or have those with which he will see clearly, and will at the same time be greatly improved in general health, he will not object to the temporary fogging, nor to the inconvenience of heavy prisms.

CHAPTER VII.

HYPERPHORIA.

Definition.—Hyperphoria signifies a tending upward of one or both of the optic axes. In right hyperphoria the right eye has a tendency to turn higher than the left eye. Left hyperphoria is the reverse; while in double hyperphoria or anaphoria both eyes tend to turn upward.

Cataphoria signifies a tendency downward of the optic axis, and may be right, left or double. If one eye tends higher than the other it is well to find out which muscle is short; but the relative position of the two eyes is generally designated as a hyperphoria rather than a cataphoria, for if the right eye, for example, tends upward it has the same relative effect as if the left eye tended downward. In other words, a left cataphoria and a right hyperphoria are identical so far as the relative position of the two eyes is concerned. The word cataphoria however is usually applied to a downward tending of both eyes.

Varieties.—Hyperphoria may be congenital, spasmodic or paretic; again it may be manifest, latent or reverse, as in exophoria.

Congenital hyperphoria is one in which the superior rectus is stronger and shorter than the inferior rectus of the same eye, or than the superior rectus of the other eye.

Spasmodic hyperphoria is a condition in which there is unequal contraction of the superior and inferior muscles of the same eye, or of the superior recti of the two eyes.

Paretic hyperphoria is a condition in which the eye tends upward because of a partial paralysis of the inferior rectus of the same eye or of the superior rectus of the other eye.

There are very few perfect eyes; scientifically speaking there are none. An optical instrument which possessed the defects of the human eye would be thrown aside as worthless. Nearly all eyes at birth are hyperopic, many are astigmatic, and as age advances all become presbyopic. The wisdom of the Creator is most wonderfully displayed in so compensating for these various defects as to produce such marvelous results.

The more numerous the anatomical parts of an organ the greater is the likelihood of some inherent defect. Had Diogenes lived to the present day and been possessed all these years of a lantern equipped with the X rays, he could not have found a muscularly perfect man. One arm is always stronger than the other, and no two eyes exist in the same person which are exactly balanced. Each eye has six extrinsic muscles, and post-mortem examinations reveal the greatest inequality in their development. A short thick muscle is frequently antagonized by one which is long and tendinous, and were the same amount of nerve force sent to the two

muscles the eye would permanently turn in the direction of the shorter.

At this point occurs the wonderful compensation of nature's forces. A stronger impulse is sent to the longer muscle than to the shorter, just as it is to the shoulder muscles when you raise your arm. But as it is exceedingly tiresome to hold the arm upwards for a great length of time, so the strain upon a weak eye muscle results in great nervous exhaustion, inasmuch as the strain is not relieved in a few moments but is continuous day after day and year after year. It is for this reason that we should make a most diligent search for the defect and as quickly as possible correct it, and thus relieve the strain. If the inequality between the opposing muscles is too great to be overcome we have double vision. But such is our natural abhorence of diplopia that if the eye cannot be held in position by excessive nerve impulse the brain soon learns to suppress the image received upon the retina of the poorer eye.

Anatomy.—The insertion of the superior rectus is the most posterior of all the long muscles of the eyeball, hence its power is least. While the eyes may be turned downward 55° or 60° they can be turned upward but 33°. This fact has an important bearing in the matter of operation for hyperphoria. (See operation.)

The axis of rotation of the superior and inferior muscles is horizontal, the inner extremity being inclined 23° forward. Hence the action of these muscles is not

simply up and down, but that of the superior is up and in, and that of the inferior down and in.

The nerve supply of both the superior and inferior recti is from the third cranial nerve, the *motor oculi*, which nerve also supplies the internal rectus, the inferior oblique, the ciliary and the levator palpebrae; hence a paralysis of the entire nerve would affect all these parts of the eye as well as the two muscles now under discussion. However, the single filament which goes to each muscle may be paralyzed without any of the others being affected.

Relationship. A. To exophoria.—Exophoria often produces an artificial spasmodic hyperphoria, which latter disappears when the former is removed by higher prisms or tenotomy. On the other hand, both heterophoriae may be genuine, each aggravating the trouble produced by the other. The rule is, *correct the exophoria first* as fully as possible. This will relieve the hyperphoria if the latter is spasmodic, while if it is genuine it will be brought more fully to light.

B. To esophoria.—Hyperphoria often causes spasmodic esophoria, which latter disappears when the hyperphoria is removed. On the other hand, both hyperphoria and esophoria may co-exist. Hence the rule in all such cases is to *remove or attempt to remove the hyperphoria first.*

C. To cyclophoria.—The superior rectus and the superior oblique both rotate the eye in the same direc-

tion, namely, the top of the vertical axis is made to incline inward toward the nose.

Conversely the inferior rectus and the inferior oblique both rotate the eyeball away from the nose. Hence a very strong and short superior rectus would not only cause a hyperphoria but also such a cyclophoria as is usually attributed to excessive action of the superior oblique or to an insufficiency of the inferior oblique. Therefore the rule is: When hyperphoria is associated with cyclophoria *correct the hyperphoria first.*

D. To hypermetropia.—Hyperphoria is at times a reflex trouble due to hypermetropia. Hence the rule: *First correct the hypermetropia even to fogging, and if the hyperphoria still persists, correct that also.*

E. To myopia.—Myopia is frequently a reflex from hyperphoria, because the spasm which is produced in the opposing long muscle brings about a similar spasm also in the ciliary as if by induction. Therefore when the two troubles are found together the hyperphoria is more genuine than the myopia, *and the rule is to correct the former first.*

Illustrative Case: Mrs. G., age 50, sent by Dr. A. C. Cowperthwaite, of Chicago, had a myopia of 20 D., associated with 30° of left hyperphoria and 6° of esophoria. All of this eye strain produced melancholia, which is a mild form of insanity. I corrected the hyperphoria, first with prisms and later by operations, thus curing her mental condition and reducing the myopia

fully 10 D. The esophoria also entirely disappeared without operation.

Causation.—Congenital hyperphoria is due to an unequal development in the superior and inferior recti of the same eye, or of the superior muscles of the two eyes. Cataphoria is due to too strong inferior recti muscles of both eyes. Anophoria is due to too strong superior recti muscles of both eyes. Prentice (p. 71 of his "Eye in Its Relation to Health") mentions fourteen autopsies in which eleven cases showed muscular inequality of the superior recti of the two eyes.

Spasmodic hyperphoria may be a reflex trouble from exophoria or hypermetropia. It may be caused from improperly adjusted prisms. One is forced to smile at statements made in textbooks of five or six years ago. Berry in his "Diseases of the Eye" (p. 401), says: "In a vertical direction any prism stronger than 4° gives rise to diplopia which cannot be overcome." An artificial hyperphoria of 10° can be produced in any case by applying improper prisms in a vertical direction. Do not be misled into thinking that if a patient will accept a prism of 10° or 12°, base up or down, that he therefore undoubtedly has hyperphoria, for such may not be the case. Spasmodic trouble in that direction is most easily produced. This same fact demonstrates the possibility of that latent hyperphoria which Savage foolishly ridicules.

Paretic hyperphoria, if associated with paresis of the other muscles controlled by the third nerve, indicates

intra-cranial trouble, and is generally due to syphillis. A paresis of a single superior or inferior rectus is generally due to a tumor in the orbit.

Symptoms and Effects.—A. Paretic hyperphoria. If there is paresis of the entire third nerve the eye is prominent, the upper lid droops, the pupil dilates and does not respond to the stimulus of light, the power of accommodation is impaired and the movement of the eye is limited upward, downward and inward.

A paresis of the superior rectus alone is indicated by the following symptoms: The movement is limited upward and inward, and the eye tends to deviate downward and outward. Diplopia, when one eye is covered by a red glass, is most marked when looking upward. The image in the affected eye is higher than the other and the upper end slightly inclines toward the nose.

Paresis of an inferior rectus shows limitation of movement downward. The eye tends to deviate upward and outward. With a red glass before one eye diplopia is increased on looking downward. The image in the affected eye is lower than the other, and its lower end is inclined toward the nose.

B. Non-paretic. The symptoms produced by hyperphoria are the same whether the trouble is spasmodic or genuine. Upon the eye it produces blurring of vision, and if very great, double vision, especially of a horizontal line. The eyes tire excessively, ache and burn, and as a result of the great strain put upon them reflex

myopia is frequently observed. Many of my patients have complained of seeing bright or dark spots before their eyes, showers as of falling soot, zigzag streaks and flashes of red light, or the vision may be very smoky and very dim. Reflex headache is exceedingly common in hyperphoria, and is associated with dizziness, staggering gait, feeling as if one would faint, sharp pains through the head, drawing in the temple, pain in the forehead and also behind the ears. Upon the mind it produces insanity. I can recount a number of cases in my private practice of melancholia which were directly due to hyperphoria, and which disappeared immediately when the latter was corrected. In fact, despondency is such a common accompaniment of hyperphoria that I question whether there is a case of suicide which did not have this muscular inequality. I have found the same condition in a number of cases of mania-a-potu.

The most constant symptom is excessive nervousness, even nervous exhaustion is frequently dependent upon hyperphoria. In three cases of shaking palsy I have found well marked trouble of the superior recti muscles. Bell's paralysis of the face (one sided), paralysis of the rectum, sleeplessness, palpitation of the heart, excessive urination and nervous dyspepsia have in my hands yielded to the correction of hyperphoria.

Other symptoms which occasionally occur are throbbing in the ears, ringing in the ears, excessive weakness, constipation and rheumatism. In cases of double hyper-

phoria or anophoria the patient is apt to hold the head downward and look out from beneath the eyebrows. This is the most frequent cause of the stoop-shoulder which precedes consumption.

Cases of double cataphoria may be recognized from the fact that the patient throws the head backward and looks down upon you as if you were almost beneath his notice. This is not due to pride but to a muscular defect of the eyes.

Single hyperphoria, if very marked, generally causes the patient to throw the head toward the opposite side.

Detection.—Formerly it was said that the displacement of the false image was always in the direction of the weak muscles. This is true in paretic and true manifest hyperphoria, but in reverse hyperphoria it is not true. We will first take up the the paretic variety. Here the mobility of the eye is impaired in the direction of the affected muscle under the red glass test. The diplopia increases as the eyes are turned toward the affected muscle, and is reduced or completely relieved when the eyes are turned in the opposite direction. As a rule the head is inclined toward the affected muscle.

By Maddox rod, which should be placed vertically before one eye, the ribbon of light in both paretic and true manifest hyperphoria is in the direction opposite to the way the eye tends to deviate. For example, in right hyperphoria if the rod is placed before the right eye the ribbon appears below the light. If placed before the

left eye it is above the light. Conversely, in left hyperphoria when the rod is before the left eye the ribbon appears below the light, and when before the right eye above the light.

In reverse hyperphoria the test simply shows what appears to be the trouble and does not reveal the reversion.

By the double prism test the middle line seen by the uncovered eye is in the direction opposite to that in which the eye appears to turn. For example, if there is a left hyperphoria and the double prism is placed before the right eye with the axis of the prisms vertical, the middle line seen with the left eye will be nearer the lower one of the two lines seen through the double prisms.

The single prism test. If a single prism of 6° or 8° is placed base down, before first one eye then the other, and the two objects thus seen appear nearer together when when it is before the right eye there is right hyperphoria. If they are nearer together when it is before the left eye there is left hyperphoria, unless a hyperphoria thus seen is spasmodic.

The strength test.—A hyperphoria may be wholly latent to diffusion tests, which can be uncovered in the following manner. With both eyes fully corrected so far as the plus refraction is concerned, place before the right eye a 2° prism base down. If the patient fuses at a distance substitute a 2½° prism in the same direction. Then a 3°, a 3½°, 4°, and so on until the point is reached at which he

can no longer fuse even though he wear the prism for several minutes. Record the highest degree of prism with which fusion in that direction is possible. Now remove the prism and allow the right superior and left inferior recti to relax from the strain under which they have been placed. After a few minutes repeat the process but this time placing the base of the prism up before the same eye, and using a little more time than in the first test, so as to give the right inferior and left superior, which act in conjunction, a fair test, and record the result. If now the eyes will fuse under stronger prisms when the base is down before the right eye there is probably right hyperphoria. If when the bases are up before the right eye they can fuse with stronger prisms there is probably left hyperphoria, and the wearing of higher prisms will demonstrate the amount. The author's new Phorometer, manufactured by L. Manasse, Co., Chicago, brings to light all of the manifest hyperphoria.

Latent hyperphoria can be determined only by the nervous and systematic effects produced by wearing higher prisms. When a true condition of latent hyperphoria is undiscovered it is of course uncorrected. The ordinary tests as heretofore described do not reveal it, and hence those who are ignorant of higher prisms ridicule and even grow wrathy at the claims of those who do use them, for the very good reasons that they have never accomplished such results, and also for the

further reason that the most serious disturbances are those which are produced by a hyperphoria which is *wholly latent* or *reverse*. Dr. Prentice has shown very clearly on page 12 of his work, that when the right superior rectus is short, instead of the eye being turned up it may be turned down, as the result of a spasm produced in the opposing inferior rectus in its effort to balance the eyes.

The usual test would fail to reveal this condition and it can only be brought to light by having the patient wear the highest prism with which he can fuse at a distance, first up and then down and noting the systematic effects.

The criterion of our work must be the effect of the glasses upon the nerve centers and the system at large. Hence if when the prism is base up before the right eye the patient is made worse but improves when the prism is reversed, and especially if he continually gets better as you use higher and higher prisms in the latter direction it proves conclusively that the trouble is right and not left hyperphoria.

Manifestations.—Blindness of one eye, paralysis, and use of prisms will render a hyperphoria visible. That is to say it will change it to a hypertropia. We can easily produce an artificial hyperphoria by using a prism, base up or down. The eyes quickly adapt themselves to the new conditions so that on removing the prism we find apparently a marked hyperphoria.

We can readily understand how a congenital defect can be entirely concealed or made latent by this same adjusting process of the eyes to meet the conditions present. For example, suppose the muscle test reveals 2° of left hyperphoria. According to Savage, prisms should be used base up before the left eye to gradually strengthen by "rythmic exercise" the "weak" left inferior rectus.

The left hyperphoria does apparently disappear, but has it been cured? No, it has simply been rendered latent. Just as eserine will cause a hypermetropia to temporarily disappear. Does the eserine cure the hypermetropia? Of course not. And yet it would be just as rational to advise the latter procedure as the former.

Savage has devoted a good many pages in advocating the use of atropine in all cases of ametropia and closes with the statement that all tests for heterophoria are unreliable when the eyes are under the influence of atropine. But in speaking of heterophoria he says, "Let us combat the known enemy and not seek out that which is hidden," evidently preferring to fall into an ambush there.

When the vision of one eye is very greatly impaired it is difficult to estimate any hyperphoria which may be present, as the image is liable to be suppressed in the eye which deviates.

Frequency.—Next to exophoria, hyperphoria is the most frequent muscular error.

Correction.—If the trouble is paralytic, treatment should be devoted to the cause, whether that be rheumatism, syphilis, diphtheria, tumor or anything else. Galvanic electricity, the negative pole being placed over the eye and the positive in the hand, is frequently a very successful treatment. Paralytic hyperphoria is at times a reflex from exophoria. Remove the cause.

In congenital hyperphoria place a prism with its base toward the long muscle, giving the full correction of manifest trouble, and increase the prism as rapidly as the latent hyperphoria becomes manifest, watching meanwhile the effect on the general nervous system. Avoid double vision through over correction, but insist on the patient wearing the glasses *incessantly*. Your patients may find when you have reached high prisms that they will see double early in the morning, the old spasm (rendering the hyperphoria latent) having returned during sleep. This is not the proof that you are working in the wrong direction. If, however, you are correct in your diagnosis, relief to the general nervous system will be quite rapid. If you are incorrect, even though you succeed in getting your patient to wear a prism of 12° or 15° base up or down with single vision, your patient's general symptoms will be made worse. In such a case reverse the process and see if the apparent right or left hyperphoria is not a reverse manifestation due to spasm of the longer muscle in its effort to overcome the congenital defect. You may have cases in which there is

no hyperphoria except what is reflex from a wholly latent exophoria. In such cases your efforts to correct the apparent hyperphoria will sometimes unlock the latent exophoria, and you may now be able to correct the latter with prisms, bases in, whereas you had striven in vain to acomplish this very thing before using the prisms vertically.

Operative measures should not be hastily resorted to. Many authors recommend operating for a manifest hyperphoria of 1° or 2°. I advise strongly against this. Wait until the hyperphoria amounts to at least 4° and preferably 5° or 6°. (See Operations.)

Prognosis.—Paretic hyperphoria often passes over to paralytic hyperphoria, and this is sometimes the precursor of locomotor ataxia, hence you can understand why treatment of hyperphoria will sometimes cure locomotor ataxia. Spontaneous recovery is not infrequent. Many cases fluctuate. For this reason you should not be discouraged if the patient gets worse, nor over-elated by a temporary improvement. So many cases not only of hyperphoria itself, but also of melancholia due to hyperphoria have been cured by higher prisms that it is no longer a question of experiment, but one of absolute demonstration that this is correct treatment, for these troubles.

CHAPTER VIII.

ESOPHORIA.

Definition.—The term esophoria is derived from a Greek word meaning *inward tending*, and it signifies that condition of the eyes in which the optic axes have a tendency to converge. It is sometimes called invisible convergent strabismus, because the eyes are held straight notwithstanding this converging tendency by a strong impulse sent to the external recti. When, however, the esophoric tendency becomes too great for the externi to resist, the squint becomes visible and is called esotropia, or cross-eye.

Nature.—Esophoria is the most deceptive of all heterophoriae because it is so often spurious. There are three varieties of esophoria—paralytic, intrinsic and false or psuedo-esophoria.

Occurrence.—While true esophoria is somewhat rare, pseudo-esophoria is very common. Paralysis of the external rectus is, however, more frequent than paralysis of all the other muscles of the eye together and produces the paralytic variety.

Causes.—Intrinsic esophoria is due to a too short internal rectus muscle, and not to a weakness of the externi, as most authors have supposed. When you consider that there is vastly more effort put forth to con-

verge the eyes as for reading than to diverge them, you see how exceedingly strong the externi must be in intrinsic esophoria to resist both the natural shortness of the interni and also the excessive nerve impuse sent to them.

Post-mortem dissections sometimes show extreme shortness of the internal recti. I once operated upon a man for cross-eye in which both internal recti were so short that he was unable to look straight ahead with either eye, but was compelled to turn his head toward the left to see with the left eye and toward the right to see with the right eye. I divided the internal recti of both eyes freely, and yet after the eyes had healed there was considerable esophoria, although the eyes could then be turned freely to either side, thus showing that the trouble was neither paralytic nor from weakness of the externi, but was due to unequal length of the recti muscles.

Pseudo-esophoria is frequently caused by hypermetropia. Savage has clearly shown the intimate relation of the origin of the nerve centers which control the ciliary and the internal recti muscles, thus associating accommodation and convergence; and he has pointed out very clearly that when one center acts the other has a strong tendency to act also. Hence, in hypermetropia, where an excessive exertion on the part of the ciliary is necessitated, in order to have sharply defined images on the retina, there is consequently an associated impulse sent to the internal recti to converge the eyes. In natu-

rally esophoric eyes this increases the esophoria, and in exophoric eyes it produces a false or reverse heterophoria.

I have now such a case under treatment, a young lad who was sent to my clinic by Dr. Boynton of this city. He has hypermetropia of $+2.50^{D}$ in one eye and $+3.^{D}$ in the other. When he uses the glasses, which correct the refractive error fully, his eyes are perfectly straight and no esophoria is manifest, but the moment the glasses are removed one eye turns clear in against the nose, showing that the esophoria is spurious, a reflex from the hypermetropia.

Relationship.—a. To Hypermetropia. As before stated, there is a very close and intimate relationship between hypermetropia and esophoria. For every dioptre of the former there is a tendency inward of one to two degrees. This is partly the result of the juxtaposition of the two centers in the brain and partly due to the habit of associating convergence with accommodation. Hence, an existing esophoria is aggravated and an artificial esophoria (or a reduction of exophoria) is produced by hypermetropia. Esophoric eyes will bear strong plus glasses easier than exophoric eyes. Hence the rule: *Correct the hypermetropia first and fully before attempting to correct the esophoria. Never operate for cross-eye until every effort has been made to correct the condition with plus glasses.*

b. To Myopia. An esophoria associated with myopia, especially if the refractive error is at all great in

amount, is usually a true esophoria. In such cases the myopia does not tend to rapidly increase, neither does the patient demand as strong minus glasses to see with as in exophoria. Hence it is quite easy to obey the rule, *give the weakest minus glass your patient can use, correcting the esophoria later if necessary.*

c. To Exophoria. Spasmodic (pseudo) esophoria is frequently a reverse exophoria. It is in this class of cases that the followers of Savage obtain their brilliant results, because the placing of prisms with bases toward the (apparently) strong muscles (the internal recti), simply uncovers and rests the overtaxed long muscles and relieves the system of its nerve strain. But instead of proving his theory to be correct, it in reality proves the reverse.

Case. Miss W., aged 26, from Lansing, Mich., was sent to me some months ago. She was suffering from great nervous irritation and severe gastralgia. She had apparently 8° of esophoria, and her physician had been applying prisms bases out to correct it. Instead of relieving the strain it aggravated it to a very great degree. She became almost wild with "nervousness." Believing it to be a reverse exophoria I tried prisms on her with bases in. The result was what might have been expected, a complete subsidence of her excitability.

In case you suspect a reverse exophoria, put on prisms *bases in and watch the effect on the general system.* If this

is good, crowd on more; if not good, stop or reverse the prisms. (See Exophoria.)

d. To Hyperphoria. Esophoria is occasionally a reflex from hyperphoria. If there is no refractive error this may be suspected where the two heterophoriae exist together. At any rate it is always safe to *first correct the hyperphoria.* (See Hyperphoria.)

Symptoms and Effect.—There are not many symptoms of the eyes in esophoria aside from weariness. We must look to the general system for the effect of the trouble. Esophoria produces certain reflexes most prominent among which are, diabetes, chorea and inability to walk straight. On page 83 of "The Eye in Its Relation to Health," by Dr. Chalmer Prentice, occurs a remarkable picture of esophoria in producing a true condition of diabetes which was cured by relieving the muscular inequality, first with glasses and later by a tenotomy.

In two cases I have markedly increased the flow of urine during the time I was testing for reverse exophoria by placing prisms bases in. This aggravated an existing esophoria. By reversing the prisms the urinary symptoms immediately disappeared. The question has sometimes been asked, "Is this guess work or science?" We reply it is science, just as the fitting of astigmatism is science. In the esophoria we have to test with prisms just as in irregular refraction we have to test with cylinders. But as in the latter when we overcorrect it makes the vision worse; so in the former, when we put on the

wrong prisms it makes the nervous system worse. You must get it out of your mind that we are merely trying to "balance" the eyes. Higher prisms are intended to relieve the nervous strain, and the criterion of our correction is the improvement produced thereby.

While true esophoria is as a rule not very injurious, there are some cases in which great harm is done by the excessive strain upon the external recti in attempting to overcome the effect of a too short internal rectus. Such a case I recently had under treatment; a young lady sent to me by Dr. Julia Woodman, of Chicago. The patient was very nervous, hysterical, morose and irrascible. She could not sleep, and was very much run down physically. She was quite myoptic requiring —2.50^{D} to bring vision up to $\frac{20}{30}$. She had apparently 5° of esophoria and 2° of left hyperphoria. All efforts to reveal a reverse exophoria failed and she even became worse under the tests. The correction of the hyperphoria did not give relief. So I began using prisms bases out. The benefit experienced was immediate and marked. She rapidly regained health under the prisms, and was cured after a tenotomy of the short internal rectus.

Another occasional effect of true esophoria is to cause inability to walk straight. Eight years ago I was called to North Platte, Neb., to operate upon several cases for Dr. J. W. Hingston, now of Chicago, Ill.

Among others he presented to me the case of a boy of five years who was excessively nervous, unable to talk

plainly or to walk without staggering and frequently falling. St. Vitus' dance or chorea was well developed. His eyes showed 10° of convergence which plus glasses would not correct. I divided the internal rectus of the right eye. The doctor reported to me later that every bad symptom shortly disappeared. The child has since developed into a strong, sturdy lad.

Dr. A. Opermann of Auburn, Neb., brought his daughter, aged 18 years to me in 1889. She was excessively cross-eyed, the convergence amounting to fully 50°. Associated with it was a great nervousness and loss of perfect co-ordination of muscular action. As the result of an operation and glasses, not only was her nervousness cured, but she regained perfect control of every movement.

Dr. Scott of Malvern, Iowa, called upon me to assist him in the case of a girl of 12 years who could not walk across the room without running into the furniture, or falling. If she attempted to carry anything she could not avoid letting it drop. Her eyes were converged 45° which plus glasses failed to correct. I operated, relieved the strabismus and cured the irregular muscular action completely. We have not space for more cases here but I could give scores of them from my own practice to illustrate the effect of heterophoriae upon the nervous system.

Detection.—a. Of apparent esophoria. By card. Hold a card as in the test for exophoria so that you can

see the covered eye. Direct the patient to fix his eyes on a distant object and suddenly swing the card so that it covers the other eye while you notice whether the eye first covered moves outward to catch the object. If it does so there is apparent esophoria. It is true this may be reverse exophoria and it is wise to test for the latter. (see Exophoria.)

b. By the red glass. When one eye is covered with a red glass both eyes being open and fixed upon a light, if two lights are seen the red one upon the same side as the eye covered with the red glass, there is apparent esophoria. The eye turning inward, the object seen with that eye, appears outward.

c. By Maddox rod. When the rod is placed horizontally before one eye, the other being uncovered and both directed to a small bright light, if the ribbon or streak of light seen through the rod passes to the temporal side of the light *i. e.* to the same side as the covered eye, there is apparent esophoria. The amount is measured by the strength of the prism placed base out which is required to cause the streak to pass through the flame. This test is very unreliable in esophoria as it invariably gives too great an amount.

d. By the double prism. If a disc containing two prisms of 6 each, bases together, (the slit between the two being horizontal,) is placed before one eye and the patient looks with both eyes at a broad black line on a card held 12 inches from the face, he will see three lines.

If the ends, or the crosses in the middle of the lines are directly one above the other there is no apparent esophoria, but if the crosses seen through the prisms are on the same (temporal) side as the prisms, there is apparent esophoria. This test is of more value at the near point than at a distance. But all tests for esophoria at the near point are of more value than those at a distance. The author's phorometer embraces this principle.

e. By the single prism. This test is easier than any of the others and when properly made is of real value. The elements necessary are that the head be held perfectly erect and that the axis of the prism be exactly vertical. When the patient looks through a 6 prism base down at a distant object, (preferably white on a dark background,) the other eye being open, two objects will be seen. If there is no hyperphoria, or if any hyperphoria present does not exceed the strength of the prism the higher object is seen through the prism. If the higher object thus seen through the prism is to the temporal side of the other, there is apparent esophoria, and the amount is measured by the strength of the prism required to bring the upper object directly over the other. Stephen's phorometer constructed on this principle is of great value.

Correction.—In correcting esophoria we must remember that hypermetropia, the action of the superior and inferior recti, and the natural excess of nerve stimulus to the internal recti, all tend to increase the heterophoria,

and also that the trouble is usually less dangerous than its opposite, exophoria, and still further that it is itself frequently a reflex trouble. Hence we must be constantly on our guard not to over-correct. We can not do as in exophoria, crowd on all the prisms with which the patient can fuse. I myself had an exophoria of 12° and yet I could fuse at a distance with prisms of 60° bases out. On the contrary we must advance only a few degrees at a time and watch the effect on the general system. If this is favorable we may proceed a step further but as soon as we find the previous symptoms becoming aggravated we must stop and retrace our steps to that point at which we obtained the best results.

The prisms should of course be worn in the position of rest, *viz.* bases out. If improvement continues until the glasses have produced visible cross-eye and the patient is wearing with comfort 20° - 30°, a tenotomy of the internal rectus of the poorer eye should be made. The extent of the operation being graduated by the amount of the heterophoria in accordance with the rules under "Operations." When there are associated with the esophoria, errors of refraction, or other heterophoriae, follow the directions under the heading "Relationship."

CHAPTER IX.

CYCLOPHORIA.

Definition.—The term cyclophoria indicates a tendency of an eye to rotate on its antero-posterior axis. The top of the vertical axis is considered the point of departure. When the tendency is for the upper aspect of the eye to incline toward the nose we designate the trouble as internal cyclophoria. This may be right, left or double.

When the top of the vertical plane tends to rotate outward the trouble is called external cyclophoria. This also may be right, left or double. For example: Right internal cyclophoria indicates a tendency of the top of the right eye to be rotated toward the nose. Left exnal cyclophoria indicates a tendency for the top of the left eye to be rotated away from the nose. Double internal cyclophoria indicates a tendency of the top of both eyes to rotate inward.

Anatomy.—There are four muscles of each eye whose individual or collective action might produce cyclophoria. These are the superior and inferior oblique and the superior and inferior recti muscles.

The superior oblique muscle arises from the margin of the optic foramen at the back of the orbit, passes forward to the upper inner angle of the orbit where its ten-

don passes through a ligament and is reflected outward and backward to its insertion in the upper part of the eyeball behind the equator. Hence its action is to pull the back part of the eye upward and inward (or the front downward and outward), and to rotate the top of the vertical plane of the eye toward the nose. Hence, when it acts alone its tendency is towards internal cyclophoria. The inferior oblique arises from the lower inner angle of the front of the orbit, passes outward and backward to its insertion almost directly behind the attachment of the external rectus and behind the equator of the eye. Hence its action is to cause the back of the eye-ball to move downward and inward (the front part moving upward and outward), and to rotate the top of the vertical plane of the eye away from the nose. This produces external cyclophoria.

The axis of rotation of the superior and inferior recti muscles is horizontal, the inner extremity being inclined 23° forward. Hence the action of those muscles is not simply up and down but that of the superior is up and in, causing internal cyclophoria, and that of the inferior down and in causing external cyclophoria. The nerve supply of both the superior and inferior recti is from the third cranial nerve, the motor oculi, which nerve also supplies the internal rectus, the inferior oblique, the ciliary and the levator palpebræ. Hence a paralysis of the entire nerve would affect all these other parts of the eye as well as the two muscles now under discussion.

Varieties.—There are three varieties of cyclophoria, namely: congenital, paralytic and spasmodic or reflex.

Causes.—Congenital cyclophoria is due to an unequal length in the opposing muscles which causes a rotation of the eyeball on its antero-posterior axis. That is to say, either the superior or inferior oblique or the superior or inferior rectus was anatomically deficient in length.

Spasmodic cyclophoria is due to an unequal contrac- of one or more of these same muscles. This may be caused by an effort on the part of the spasmodically contracted muscle to overcome the result of a defective length of its opponent, or it may be reflex from astigmatism, or from a hyperphoria or an exophoria.

Paralytic cyclophoria is generally due to paralysis of the fourth cranial nerve, the "patheticus." This paralysis may be central, that is, due to some disease of the brain or its covering, the meninges; or it may be due to a tumor in the bony orbit of the eye. Again paralysis of those fibers of the third nerve which supply the superior or inferior oblique would produce cyclophoria.

Symptoms and effects.—In my patients suffering with cyclophoria I have observed persistent headache in the forehead and temples; patient never free from headache; excessive nervousness, inability to sit still; pain in the eyes, worse on use. I have had three cases of shaking palsy or paralysis agitans in which the cyclophoria was markedly developed.

Detection.—First by a single prism. If a prism of 6°

or 8° is placed base down before one eye so that the two eyes are disassociated, a long card which stands vertically against the wall twenty feet away will appear to incline in a direction opposed to the short muscle. Or if the cyclophoria is paraletic it will incline toward the direction of the paralyzed muscle. For example, if the right superior oblique is shorter than it should be, or if the right inferior oblique is paralyzed, the top of the card as seen by the right eye, will incline toward the right, while if the inferior oblique is shorter than it should be, or if the superior oblique is paralyzed, the top of the card seen with the right eye will incline to the left.

With a double prism. When a double prism is placed before one eye, with the slit between the prisms horizontal and the patient looks at a broad horizontal black line on a piece of paper held ten or twelve inches from the face, two parallel lines will be seen through the prism. If the other eye is now uncovered a third line will be seen which is presumably between the two. If there be internal cyclophoria of the uncovered eye the line seen with that eye will point downward and outward. If there is external cyclophoria of the uncovered eye this line will point upward and outward.

With the Maddox rod. The streak of light which should be vertical as seen through the Maddox rod when the latter is placed horizontally, inclines upward and outward if there is internal cyclophoria, and upward and inward if there is external cyclophoria.

Relationship.—A. *To astigmatism.* Oblique astigmatism, as Savage has so clearly shown in "New Truths in Ophthalmology," often produces a spasmodic cyclophoria, because of the effort which is put forth to cause the same point of the external object to be seen by the corresponding points of the two retinæ. Owing to the fact that the eyes have been twisted for years before the astigmatism was corrected, it is found to be exceedingly difficult to give a full correction for oblique astigmatism, especially if of high degree, without producing pain, eye-strain and nervous symptoms. In order to obviate this Savage has suggested the use of cylindrical lenses placed successively at different axes for the purpose of strengthening the weak muscles through rythmic exercises. This method is a difficult one to carry out, but is frequently successful in purely spasmodic cases. The fault is in his theory and not in his application. For such cases being due to spasm and not to an anatomical defect, are benefitted by producing an opposing spasm, or in other words, by relaxing the original spasm. The same result, however, can be obtained in a much easier manner and one which opticians can use, as they cannot use Savage's method.

That is, instead of correcting the entire oblique astigmatism, at first only correct half of it if of high degree, and correct any other heterophoriæ which may be present. In this way you may find that the astigmatism itself is partly spasmodic, and that when the other

heterphoriæ are corrected the spasmodic cyclophoria will have disappeared. Eventually it may be necessary to correct three-fourths, even nine-tenths, of the astigmatism, but this is hardly probable.

B. *To Exophoria.*—Cyclophoria is frequently a reflex from exophoria. Hence this rule: Correct the exophoria first and fully before paying attention to the cyclophoria.

C. *Hyperphoria.*—Cyclophoria is frequently a reflex from hyperphoria. Hence, if any hyperphoria exists, correct it first. The hyperphoria may be wholly latent, in which case it will have to be uncovered by the methods described in the lecture Hyperphoria.

Correction.—The correction of cyclophoria is a subject which has given rise to a great deal of discussion among prominent oculists. Savage claims that the putting on of a cylinder at an oblique axis and moving it fifteen degrees every few minutes in such a direction as to bring into play the so-called weak oblique muscle will stimulate it to excessive action and thus restore its strength. If his theory of causation were correct his method would be the logical outcome. It is true that he can "balance" the eyes by his method of procedure, but he does so at the expense of nerve power. Our theory is this: that we should conserve the nerve force by removing the cause of the trouble, and as the cause of cyclophoria is generally a reflex hyperphoria, exophoria or an oblique astigmatism the correction of these primary troubles will cause the hyperphoria to disappear.

When all other heterophoriae have been removed if the cyclophoria still presists and causes distressing symptoms it should be removed by a tenotomy of the short oblique muscle. This condition, however, is so exceedingly rare that it will be encountered but once or twice in a life time, and when it is found, the case should be sent to a competent oculist.

CHAPTER X.

OPERATIONS.

Definition.—The operations for heterophoriae consist of tenotomies and advancements. A tenotomy is a division of the tendon of one of the long muscles at its point of attachment or insertion into the sclera. A tenotomy may be either partial or complete, as described later. Advancement is an operation whereby the attachment of one of the recti muscles is brought forward.

Anatomy.—The four recti muscles arising at the apex (back) of the bony orbit pass forward, diverging as they do so and are attached by their tendinous extremities to the sclera in front of the equator of the eye at a distance of from 5.5 to 8 millimeters back of the corneal margin. The attachment of the internal rectus is most anterior and that of the superior rectus most posterior.

The superior oblique also arises at the same place but at the upper inner angle of the front of the orbit it passes through a pulley and is reflexed backward and outward, and its tendon spreading out to a fan shape is inserted into the upper and outer part of the globe behind the equator under the superior rectus.

The inferior oblique arising at the lower inner angle of the margin of the orbit passes outward and backward beneath the inferior rectus and is inserted into the outer

part of the sclera behind the equator under the external rectus.

Covering the eyeball and tendons of the recti muscles is a strong semi-transparent membrane called Tenon's capsule, which must be opened in order to get at the attachment of the tendons. Still in front of this is the delicate conjunctiva or skin of the eyeball.

The muscles should be so developed and of such length as to maintain an exact balance between opposing pairs when the eyes are in a state of rest.

The defect.—The greater the number of parts the greater the dissimilarity of any two organs. The two hands are seldom equally developed, and the two legs are rarely of exactly equal length, while the two eyes are as a rule not exactly balanced in their muscular action. Post-mortem examinations reveal great inequalities in length and development of co-ordinate muscles.

The internal and external recti are scarcely ever of equal power, length or development. If the inequality is not too great the nerve centers are able to send out enough impulse to the weaker muscles to cause the eye to be directed aright in spite of its anatomical defect.

Theory.—The condition of balance of unequal muscles as just described is however maintained at the expense of great nervous energy, and it is for the purpose of relieving this drain upon the nerve centers that operations are performed when the eyes do not visibly turn from the true line.

The opposing muscles being of different lengths the shorter muscle has too strong an action so that it overbalances the long muscle, or if the long muscle is greatly developed in its muscular part the short one is stretched unnaturally. Hence, we may carefully detach the strong muscle from its insertion into the eyeball and allow it to fall further back where it will re-attach itself to the eyeball, thus weakening its power to turn the eye so that it will exactly balance the other muscle, or if it has been stretched it will recover because the occasion for stretching by its antagonist is removed, its attachment further back allowing the eye to turn toward its antagonist without thus stretching it. On the other hand, the longer muscle may be advanced and re-attached by stitching, so as to give it more power upon the eyeball and thus balance the shorter muscle. The modus operandi is described later.

Indications for operations.—Authorities differ widely as to when operations should be performed. Thus Savage says, P. 108, "On the operative side of a safe line between operative and non-operative cases must be placed all cases in which the plain red glass produces diplopia." Later he adds, "While the line is a safe one it is not sufficient. While there are many cases that under ordinary circumstances have binocular single vision in whom the red glass will develope diplopia, there are many more cases of heteroporia sufficiently great to demand operative interference in whom the red glass is

incapable of bringing about diplopia. All exophoria for distance should be relieved by operation. All intrinsic esophoria in the near should be corrected by operation; hyperphoria and cataphoria of 2° or more should be operated upon." P. 112, "Under the exclusion tests should the eyes reset in both the distance and near tests there is certainly enough error not only to justify but to demand operation."

Nearly all authorities claim that all visible deviations should be operated upon, but I have heard oculists in conventions speak of the turning out of many eyes upon which they had operated for marked convergence. I I never had but one case of the kind myself and that was before I knew anything about Higher Prisms. I have seen cases of convergent strabismus due to reversely manifested exophoria in which a division of the external rectus produced perfect results, after Higher Prisms had brought the true defect to light. Panney operates for six degrees of esophoria or exophoria and two degrees of hyperphoria. I prefer the motto: "Better safe than sorry," hence do not operate unless there be manifest at least 4° of hyperphoria, 10° of exophoria, or 15°—20° of esophoria.

Manner. Instruments. The instruments needed are (1) a pair of very sharp scissors curved slightly on the flat with blunt points, but cutting to the very end. (2) Two tenotomy hooks, one very small and one having a crochet-needle point. (3) A pair of forceps with a

self catch. (4) Eye speculum. (If you have an assistant this is not required.) (5) A fine curved needle and holder. You may also need some fine catgut and plenty of absorbent cotton. A good light is requisite but an operating chair is not necessary.

Preparations.—Having fully determined which eye should be operated upon, the eyelid and in fact the entire side of the face should be thoroughly washed with castile soap and water and wiped with a clean towel or cotton. The surgeon's hands and those of his assistant should be scrubbed so as to remove every possible source of contamination. The instruments should be steamed thoroughly or scalded and then wiped dry or kept in water that has been boiled. A little boracic acid may be added to the water if desired, but bichioride of mercury should not be used about the eye even in small quantities. For myself I have discarded all antiseptics and simply use aseptic boiled water. The patient may be placed on an operating chair or table or he may sit up in a high-backed chair with his face to a window.

The instruments should be placed to the right of the oculist or held by a second assistant. A cup of water that has been boiled and several pledgets of cotton on a tray complete the paraphanalia.

Anæsthetic.—If the patient is a child or an exceedingly nervous woman it may be best to give chloroform, but as a rule cocaine is all sufficient.

Modus Operandi—A few drops of a 20 per cent solu-

tion of cocaine having been put in the eye ten minutes previously and the patient assured that the operation is perfectly painless and free from danger (I have operated 500 times without the loss of a single eye), the physician takes his place with his instruments on a stand at his right. If the external rectus of the left eye or the internal rectus of the right eye, or either of the inferior recti are to be cut, the operator's position should be behind the patient if sitting, or at his head if reclining. For the external rectus of the right eye or the internal rectus of the left eye or either superior recti, the operator should be at the left of the patient.

An assistant now holds the lids open with his thumbs firmly pressed against them. The patient is directed to look at some fixed object in the opposite direction from the side operated on. With a pair of forceps in the left hand the surgeon now siezes about one-fourth inch of the conjunctiva just back of the attachment of the tendon to be divided, the forceps being made to include also the Tenon's capsule and the tendon. With the scissors in the right hand a free cut is now made through the fold of the tissues held in the forceps. If the capsule or tendon have not been cut they must be picked up through the wound already made and cut through.

The initial cut should be at the center of the tendon's attachment, and not at its lower edge as formerly advised, for the reason that much less injury to the subconjunctival tissues results in this way. The small

tenotomy hook is now introduced into the wound and slipped under the undivided upper part of the tendon whose attachment is thus made to appear. This is now divided more or less completely close to the eyeball. The hook is next passed under the lower portion of the tendon, which is divided in like manner. The patient is now directed to look at a light twenty feet away, and the balancing of the muscles tested.

If all of the heterophoria has not disappeared, the eye is not yet straight and you must search for uncut fibers. You may possibly have to increase the effect by a later operation upon the other eye. If you have cut too much you must put in a stitch to bring back the eye to balance.

It is not necessary to stitch the external rectus even if you have overdone it, provided there were 14° of exophoria before operating. A partial tenotomy only differs from a complete one in this, that all the fibers are not divided, but the extreme outside fibers are left intact. A partial tenotomy is performed for slight amounts of heteraphoria, especially in hyperphoria and esophoria. In exophoria it does not produce as much represison of abnormal nerve impulse as a complete operation does.

An advancement differs from a tenotomy only in this: that when the attachment of the tendon has been severed a small piece is sometimes removed, three sutures are passed through the tendon, and it is pulled forward and

stitched to the under side of the corneal lip of the wound in the conjunctiva and Tenon's capsule.

Advancement is indicated in exophoria following an operation for convergent strabismus, or in those cases where the long muscle is almost wholly tendinous so that but little results have been affected by tenotomies of the opposing muscles.

The after treatment is very simple. Blood has been found to be the best antiseptic, hence it has long been my practice to dress the eye "in the blood." That is, not to wash the blood away, but simply wipe off carefully the clots, if any, and what has exuded from between the lids. I bandage the eye for one hour only, and then have the patient remain in the house for twenty-four hours and keep the eye open the same as the other.

Prognosis.—The wound generally heals by the third day, but the redness sometimes remains for two weeks or more.

A complete tenotomy of the external is sometimes, though rarely, followed for two or three weeks by a slight convergent squint, which soon passes off.

A too complete division of the internal rectus, especially if spasmodic (see hypermetropia) is sometimes followed by a turning out of the eye (see exotropia). Hence, never operate for convergent strabismus until after having repressed with strong plus glasses.

Benefits.—When indicated an operation will accomplish all that higher prisms do and a great deal more,

because the repression is thus kept up by night as well as by day. Ranney says: "If a patient experiences no benefit from the wearing of prismatic glasses properly prescribed, but is relieved at once of nervous symptoms by a radical correction of the existing errors of adjustment of the eyes through a tenotomy, it seems to me most absurd to argue that glasses are as effective in the treatment of heterophoria as are tenotomies when properly performed."

CHAPTER XI.

HOW TO PROCEED.

Reception.—In dealing with patients the great object is to cure them quickly, safely, pleasantly. The consideration of the highest importance is honesty. Never misrepresent and you will prosper. But in order to be honest it is not necessary to tell your patient everything. If you are in doubt as to anything try to find out but do not let your patient know your perplexity.

Study, think, test. Carefully weigh every argument pro and con, but before your patient preserve an air of confidence. Hold him until you reach your conclusion and the outcome will be satisfactory to you both. However, when you are convinced that you cannot benefit him tell him so frankly in order that he may seek aid elsewhere.

Kindliness. Always treat your patients with the most kindly consideration. "Do to others as you would be done by." People have feelings and he who is considerate of others feelings will have the most friends and the most business. Do not become impatient if the answers come slowly. Often the most accurate are the most hesitating.

Beware of a flashy patient. Eyes that twinkle are deceitful. If the patient contradicts himself it is no rea-

son why he should be censured. He does not mean to lie. The very contradiction is a valuable symptom as it shows spasm of the muscle tested whether it be the ciliary or one of the recti.

Appearances.—Be neat and tidy. Never have dirty finger nails or soiled linen and if you must wear old clothes see to it that they are nicely brushed and clean. Above all wear a genial, pleasant expression and smile oftener than you frown.

Place.—If possible have a room fitted especially for refraction work. Not extravagantly furnished but very neat and clean, and as prettily arranged as you can. It should if possible be twenty feet long and either well lighted with a large window or provided with electricity. One of the best testing rooms I ever saw was in a jeweler's basement. A broad easy flight of stairs led down to it. The illumination was by incandescent burners with shields which both protected the patient's eyes and reflected the light upon the charts. A hole through one of these served for the Maddox-rod test. An easy chair should be provided for the patient and another for his company. A good trial case, books of reference and whatever other instruments you may have help to make a good impression.

Record.—An accurate record should be kept of each time the patient is treated, giving vision with and without glasses; effects on general system; noting any general symptoms which may arise or disappear; also

the results of tests, and suggestions for future treatment, etc.

Tests.—First test vision of each eye without glasses at twenty feet. If they cannot see the top letters at that distance have them approach until they can and record the result. Then fit each eye with glasses to correct all errors of refraction; record the same; then add plus spheres until vision is 20-30, or if myopic 20-40 and record the results. Then returning to the glasses with which vision was best, test the muscles, first using the Maddox rod, single and double prisms, both for distance and near point and record the results. See how many degrees of prisms, bases in, up and down can be used and fusion at a distance be preserved. Always add $+2^D$ to 3^D before testing the muscles at the near point.

Correction.—If you find a high degree of error in the refraction or discover or have reason to expect a large amount of heterophoria be very cautious of what you may say about a speedy cure. Rather say that the probilities are that it may take some time and possibly a great many glasses. Then you will not have the humiliation of having your patient leave you just as you are beginning to reap results. I often use this little illustration with my patients, "If you are climbing a long flight of stairs you cannot go from the bottom to the top at once; you must go up a step at a time. So here, there is a large error. I cannot correct it at once for you would not be able to wear the glass which would be required, but I

must correct part today, and more tomorrow or next week and eventually we will have it all done." They say. "Well, Doctor, how much error is there, and how long will it take?" I tell them how much refractive error there is as revealed by the various tests, but say "I do not know how much muscular error there is; I can detect so many degrees. How many more are latent or hidden, I do not know. I will correct all you can stand now, and that will bring to light any more that may be hidden, and then we can correct that. When all is corrected no more will appear. Just as when walking in the dark with a lantern you cannot see the end of your journey at first; only a little way is lighted; take one step and you can see the next, and so on to the end."

Have the patient wear each prism or combination as long as it is satisfactory, provided you are not rushing the case for a quick result. In the latter case if a large amount of exophoria appears at the near point change glasses every two or three days and crowd on all the prisms bases in, with which the patient can fuse.

First correct the hypermetropia to the full of perfect vision, and if the patient will stand it a little more, but under correct the astigmatism especially if it be plus and axis 90 or oblique, and also minus with axis 180° or oblique. Undercorrect or entirely omit a correction for myopia especially if the ophthalmoscope shows normal refraction. Correct an exophoria 4° at a time (possibly only 2° the first time), but always give glasses within

fusion limits. *Never correct more exophoria for distance than shows at the near point under fogs, nor more esophoria than appears at the near point.*

When all exophoria is corrected or when you have reached a point where any further adding of prisms, base in, tends to aggravate the case go back to the prism with which you had the best results and begin correction of any hyperphoria present, and continue until no more developes, or until you aggravate the condition than go back again to the point of best results.

If you have reached 10° of exophoria with fusion for 25° base in, or 4° of hyperphoria with fusion for 7° up or down a tenotomy may be performed.

If an esophoria is the only muscular error and no other can be developed simply give strong plus glasses to the limit of the ophthalmoscopic test and if the general symptoms do not improve try prisms base out, but be very watchful and if they at all aggrevate immediately remove them.

Should a cyclophoria be present for a month, after correcting all manifest exophoria, hyperphoria and astigmatism, test the eyes again and again and see if more heterophoria may not develope. If it does not, an operation may be indicated.

After all muscular errors have been corrected by prisms or operation the glasses with which vision is best may be used, care being taken to give as strong plus glasses as possible.

CHAPTER XII.

EXAMINATION QUESTIONS.

Answers to all of these questions may be found in the book. It is prefered that the student use his own language and not the words of the text. Answers should be numbered to correspond with the questions. If possible, have the answers typewritten. If mistakes are made students will be notified so that they may correct them.

1. Of what does Higher Prisms treat?
2. What is an ocular reflex?
3. What is the need of the study of higher prisms?
4. What is a safe criterion of the accuracy of a prescription of prisms?
5. What is a prism?
6. How do you determine the axis of a prism?
7. How is a ray of light refracted in passing through a prism?
8. What is Savage's theory?
9. Wherein is it defective?
10. Name the extrinsic muscles of the eyeball.
11. Which is the longest and which is the shortest?
12. Which are inserted in front of the equator?
13. Which turn the eyes up ?
14. Which turn them in?
15. Which act together in converging the two eyes?
16. If I wish to look up and to the left which muscles are brought into action on each eye?
17. Are corresponding muscles usually developed in an exact degree?
18. Why is the service required of eye muscles so exacting upon the nervous system?
19. What is the important thing in treating defects of the ocular muscles?
20. Are any two cases exactly alike?

21. What is the underlying principle on which all phorometers are constructed?

22. How is this accomplished?

23. In what direction does the false image always go?

24. What effect does a multiplicity of images have?

25. Wherein is the strong plus sphere defective as a test for heterophoria?

26. Name some of the best tests.

27. What advantage is gained by the use of the tropometer?

28. What is exophoria?

29. How often is it found?

30. What are the three varieties?

31. Which is the short or strong muscle?

32. What brings a latent exophoria to light?

33. Name some symptoms characteristic of exophoria.

34. Does it conserve the nervous powers or not?

35. Name some organs upon which it produces reflex irritations.

36. Name one manner of detecting it.

37. Does the false image go toward the nose or temple in exophoria?

38. In exposing latent or reverse exophoria, how much should the glasses be worn?

39. Where should the bases of the prisms be placed?

40. If this makes the patient's general symptoms worse, what conclusion must we reach?

41. If there is a marked hypermetropia, what should be done?

42. If the two eyes are unlike in visual power, how can you avoid the suppression of one image?

43. If a fog and prism produce a sensation of weakness, is it a bad sign?

44. If exophoria and myopia coexist, which is usually the cause of the other, and therefore first to be removed?

45. If exophoria and hyperphoria coexist, which should be first eliminated?

46. Will removal of exophoria ever reduce an astigmatism?

47. Is it possible to produce an artificial esophoria in an exophoric eye?

48. Where should the base of the prism be placed to relieve an exophoria?

49. How strong should the first prisms be?

50. What inconvenience is often experienced upon first wearing prisms?

51. As more exophoria becomes manifest should it be corrected?

52. When should a tenotomy be performed?

53. Of what benefit is fogging?

54. What precaution should we always use in prescribing prisms, bases in?

55. How often should lenses be changed?

56. What is hyperphoria?

57. In exactly what direction does the superior rectus move the eye?

58. To what form of heteraphoria is myopia often due?

59. In which way does the eye deviate in paresis of a superior rectus?

60. What kind of a line is apt to appear double in hyperphoria?

61. In double hyperphoria how does the patient hold the head?

62. In paretic hyperphoria the diplopia increases when?

63. Will the correction of hyperphoria ever reveal latent exophoria?

64. What is esophoria?

65. How many varieties?

66. Cause of each?

67. How do esophoric eyes bear strong plus glasses?

68. Which should be corrected first, esophoria or hypermetropia?

69. How should pseudo-esophoria be treated?

70. Name some of the reflexes produced by esophoria.

71. In esophoria the false image goes to which side, nasal or temporal?

72. In esophoria which test is more reliable, that at a distance or the one at the near point?

73. In correcting esophoria is it advisable as a rule to correct all of the error shown?

74. What is cyclophoria?

75. Which muscle is too short or spasmodically contracted in right external cyclophoria?

76. How far may the normal eye be turned up? Down?

77. What most frequently causes spasmodic cyclophoria?

78. How can you with comfort to the patient correct a high degree of oblique astigmatism?

79. Is it wise to fully correct an oblique astigmatism?

80. Which should be corrected first, exophoria or cyclophoria?

81. How may cyclophoria be detected?

82. How corrected?

83. What is a tenotomy?

84. Through what tissues must we cut to get to the tendon?

85. Why should a tenotomy be performed when the eyes do not visibly turn from the true line?

86. If a muscle is detached from the eyeball will it reattach itself again? If so, where?

87. Should all cases which show diplopia with a red glass before one eye be operated upon?

88. What anæsthesia is used?

89. What is the best antiseptic?

90. Will an operation do as much as prisms?

91. What is the great object in dealing with patients?

92. What are some of the qualities which an operator should possess?

93. What do contradictory answers often indicate?

94. What sort of a room is preferable for optical work?

95. What is the benefit of a record book?

96. When can you not promise a speedy cure?

97. How can you hold a patient with a large amount of heteraphoria until all is corrected?

98. In esophoria what means should be used before prisms are resorted to?

99. When should the glasses which give the best vision be used?

100. Of what benefit have these articles on Higher Prisms been to you?

Send answers to the author, Dr. E. T. Allen, 92 State Street, Chicago, who will examine papers gratis. To those who attain 90 per cent. in this examination, a beautiful Latin certificate or diploma, 18 x 23 inches in size, will be issued upon the nominal payment of $5.00. The following parties have already won this certificate:

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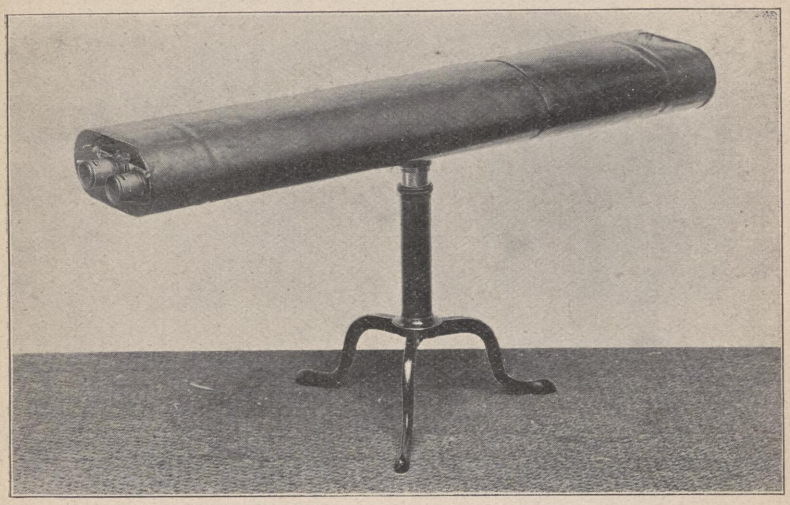

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